PROCEEDINGS

AND

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

VOL. XXV.

SESSION 1910-1911.

LIVERPOOL

C. Tinling & Co., Ltd., Printers, 53, Victoria Street.

1911.

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PROCEEDINGS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

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1905—1906 JOSEPH LOMAS, F.G.S.
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1907—1908 W. T. HAYDON, F.L.S.
1908—1909 Prof. B. MOORE, M.A., D.Sc.
1909—1910 R. NEWSTEAD, M.Sc., F.E.S.

SESSION XXV., 1910-1911.

President:

Prof. R. NEWSTEAD, M.Sc., F.E.S.

Vice-Presidents:

Prof. W. A. HERDMAN, D.Sc., F.R.S.
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Prof. SHERRINGTON, F.R.S
W. THELWALL THOMAS, Ch.M., F.R.C.S.
E. THOMPSON.
L. R. THORNELY.

Representative of Students' Section:

H. G. JACKSON, B.Sc.

REPORT of the COUNCIL.

During the Session 1910-11 there have been seven ordinary meetings and one field meeting of the Society.

The communications made to the Society at the ordinary meetings have been representative of almost all branches of Biology, and the various exhibitions and demonstrations thereon have been of great interest.

By invitation of the Council, Dr. A. E. Shipley, F.R.S., of Cambridge, lectured before the Society, at the February Meeting, on "Grouse Disease."

The Library continues to make satisfactory progress, and additional important changes have been arranged.

The Treasurer's statement and balance-sheet are appended.

The members at present on the roll are as follows:—

Ordinary members	47
Associate members	6
Student members, including Students' Section	37
Total	90

SUMMARY of PROCEEDINGS at the MEETINGS.

The first meeting of the twenty-fifth session was held at the University, on Friday, October 14th, 1910.

The President-elect (R. Newstead, M.Sc., F.E.S.) took the chair in the Zoology Theatre.

1. The Report of the Council on the Session 1909-1910 (see "Proceedings," Vol. XXIV., p. viii.) was submitted and adopted.
2. The Treasurer's Balance Sheet for the Session 1909-1910 (see "Proceedings," Vol. XXIV, p. xviii) was submitted and approved.
3. The following Office-bearers and Council for the ensuing Session were elected:—Vice-Presidents, Prof. Herdman, D.Sc., F.R.S., and W. T. Haydon, F.L.S.; Hon. Treasurer, W. J. Halls; Hon. Librarian, May Allen, M.A.; Hon. Secretary, Joseph A. Clubb, D.Sc.; Council, H. C. Beasley, J. Johnstone, B.Sc., J. Share-Jones, F.R.C.V.S., Prof. B. Moore, M.A., D.Sc., W. S. Laverock, M.A., B.Sc., Douglas Laurie, M.A., J. H. O'Connell, L.R.C.P., H. E. Roaf, D.Sc., Prof. Sherrington, F.R.S., W. Thelwall Thomas, Ch.M., F.R.C.S., E. Thompson, and Laura R. Thornely.
4. R. Newstead, M.Sc., F.E.S., delivered the Presidential Address on "Zoological Observations in Malta" (see "Transactions," p. 1). A vote of thanks was proposed by Mr. Haydon, seconded by Mr. Laverock, and carried with acclamation.

The second meeting of the twenty-fifth session was held at the University, on Friday, November 11th, 1910. The President in the chair.

1. Prof. Herdman submited the Annual Report on the work of the Liverpool Marine Biology Committee and the Port Erin Biological Station (see "Transactions," p. 3).

The third meeting of the twenty-fifth session was held at the University, on Friday, December 9th, 1910. The Vice-President (Prof. Herdman) in the chair.

1. Dr. H. B. Fantham exhibited a preparation and drawings of a new trypanosome (*T. rhodesiense*), from a case of sleeping sickness contracted in Rhodesia, and described by Dr. Stephens and himself.

   The patient, an Englishman, had never been in an area infested by *Glossina palpalis*, though he had been in districts in which *Glossina morsitans* abounded, also in one district in which *Glossina fusca* occurred.

   The trypanosome exhibited long forms, and short, stout or stumpy forms with hardly any free flagellum. The trypanosome is unique in that about six per cent. of the parasites (especially the stumpy forms) have the nucleus at the *posterior* (non-flagellar) end, near the blepharoplast, and in some cases actually posterior to the blepharoplast. These posterior nuclear flagellates can be seen in life, by appropriate staining with methylene blue or neutral red. Dividing forms of this trypanosome occur, so that they are not degenerating. The trypanosome, for which the new specific name *T. rhodesiense* was proposed, is of marked virulence, and is resistant to drugs. Its morphological peculiarity persists in rats, guinea-pigs, rabbits, monkeys, horses and dogs.

It is also of interest to add that a trypanosome with precisely similar morphology has since been described by Stannus and Yorke from a case of sleeping sickness in Nyasaland, where *Glossina morsitans* is common.

2. Dr. Dakin submitted a paper on some peculiar Invertebrate sense organs, in which the minute structure of the eyes of Pecten was contrasted with similar structures in other Invertebrates.

3. Miss E. N. Tozer communicated a paper on the sense organs of muscles of mammals.

The fourth meeting of the twenty-fifth session was held at the University, on Friday, January 13, 1911. The President in the chair.

1. Dr. Roaf contributed a note on the purple gland of *Purpura lapillus*.

2. Mr. Wm. Riddell, M.A., gave some records for the occurrence of certain species of Annelids at Port Erin (see "Transactions," p. 56).

3. Mr. Douglas Laurie, M.A., gave a paper on "Thumb-marks." Various types of markings were described, and the hereditary transmission of these characters was discussed in relation with the Mendelian theory.

The fifth meeting of the twenty-fifth session was held at the University, on Friday, February 10th, 1911. The President in the chair.

1. Dr. A. E. Shipley, F.R.S., of Cambridge, lectured before the Society on "Grouse Disease," and gave a graphic account of the animal parasites of the grouse and their life-histories.

The sixth meeting of the twenty-fifth session was held at the University, on Friday, March 10th, 1911. The President in the chair.

1. Mr. H. C. Beasley exhibited and described a cast of the footprint of *Thinopus antiquus*, the earliest air-breathing Vertebrate known.
2. A note on *Jassa falcata* by Mr. Alf. O. Walker, F.L.S., was communicated (see "Transactions," p. 67).
3. Prof. Herdman submitted the Annual Report of the Investigations carried on during 1910 in connection with the Lancashire Sea Fisheries Committee (see "Transactions," p. 73).

The seventh meeting of the twenty-fifth session was held at the University, on Friday, May 12th, 1911. The President in the chair.

1. Prof. Herdman exhibited, with others, a series of interesting specimens from Port Erin.
2. Dr. H. B. Fantham exhibited some diseased bees and combs infected with a minute pathogenic protozoal parasite, apparently the same as *Nosema*

apis found by Zander in diseased bees in Bavaria. Microscopic preparations and sketches of the parasite, *Nosema apis,* were also shown, as well as healthy bees and combs in contrast.

Dr. Fantham remarked that the material exhibited was obtained from the Cambridge-Hertfordshire border, in March, 1911. The parasite, *Nosema apis,* was first found by Dr. Fantham and Dr. Annie Porter, in 1906, in diseased bees obtained from the Isle of Wight. It was again found by them in diseased bees from the South of England in 1907, but owing to the great difficulty of obtaining material, and to the pressure of other work, their results were not published.

The parasite, *Nosema apis,* is a Protozoön forming many minute spores, and belongs to the Sporozoa, sub-division Microsporidia. It infests the digestive tract of the bee, growing and multiplying within the lining epithelium of the gut (especially the chyle-stomach and intestine), causing a sort of dry dysentery. In the opinion of Dr. Fantham and Dr. Porter this micro-sporidian parasite has been responsible for much of the bee disease recorded in England (especially in the Isle of Wight and the South) since 1906.

The minute spores, about 2 μ by 5 μ, are formed in large numbers in infected bees, and foul the hives. These spores are very resistant, and are the cross-infective stages of the Protozoön. The parasite, *Nosema apis,* is closely allied to that of pébrine, the silkworm disease due to *Nosema bombycis,* which caused such ravages in France years ago.

It is probable that young, growing, and multiplicative stages (the trophozoite and pansporoblast) of *Nosema apis* are capable of killing bees before the formation of spores has been attained, for dead bees were often found in which only young stages of the parasites could be detected.

Like *Nosema bombycis*, the bee-parasite was possibly capable of hereditary infection, as infected bee larvae and a dead infected queen had been found and examined. Maassen had recently found infected drones in Germany, but the infection in drones was stated to be limited to the intestines.

That *Nosema apis* was fatal to bees and allied Hymenoptera had been shown by feeding healthy hive bees, mason bees and wasps with honey infected with *Nosema* spores; also by placing hive bees dead of the disease among healthy hive and mason bees and wasps, and by direct contamination of healthy bees with infected faecal matter. In each case the insects experimented upon succumbed to the effects of *Nosema apis*.

It should be noted that the virulence of the parasite appeared to vary in bees at different times of the year and in different localities. The bees were especially prone to the disease after bad seasons, such as had occurred in recent years. Some bees became chronics, forming reservoirs of spores, and so acting as parasite-carriers.

The only certain destructive agent of the Microsporidian spores is fire, and all infected bees and hives, and any débris therefrom should be most carefully burned.

Microsporidiosis (due to *Nosema apis*) had probably been introduced from the Continent into British apiaries.

Several other injurious parasites may occur in bees, but *Nosema apis* is certainly one which must be guarded against.

The eighth meeting of the twenty-fifth session was the Annual Field Meeting held at Burton Point, on Saturday, June 17th. At the short business meeting held after tea, on the motion of the President from the chair, Dr. J. H. O'Connell, was unanimously elected President for the ensuing session.

LIST of MEMBERS of the LIVERPOOL BIOLOGICAL SOCIETY.

SESSION 1910-1911.

A. Ordinary Members.

(Life Members are marked with an asterisk.)

ELECTED.

1908 Abram, Prof. J. Hill, 74, Rodney Street, Liverpool.

1909 *Allen, Miss May, M.A., Hon. Librarian, University, Liverpool.

1910 Barratt, Dr. J. O. Wakelin, Cancer Research Laboratory, University, Liverpool.

1888 Beasley, Henry C., Prince Alfred Road, Wavertree.

1908 Bigland, H. D., B.A., Shrewsbury Road, Birkenhead.

1903 Booth, jun., Chas., 30, James Street, Liverpool.

1886 Caton, R., M.D., F.R.C.P., 78, Rodney Street.

1886 Clubb, J. A., D.Sc., Hon Secretary, Free Public Museums, Liverpool.

1909 Dakin, W., D.Sc., The University, Liverpool.

1910 Fantham, Dr. H. B., School of Tropical Medicine, University, Liverpool.

1902 Glynn, Dr. Ernest, 62, Rodney Street.

1903 Guthrie, Dr. Thomas, 9, Canning Street, Liverpool.

1886 Halls, W. J., Hon. Treasurer, 35, Lord Street.

1910 Hamilton, Mrs. J., 92, Huskisson Street, Liverpool.

1896 Haydon, W. T., F.L.S., Vice-President, 55, Grey Road, Walton, Liverpool.

1886 Herdman, Prof. W. A., D.Sc., F.R.S., Vice-President, University, Liverpool.

1893 Herdman, Mrs. W. A., Croxteth Lodge, Ullet Road, Liverpool.

1897 Holt, Alfred, Crofton, Aigburth.

1902 Holt, A., jun., Crofton, Aigburth.

1903 Holt, George, Grove House, Knutsford.

1903 Holt, Richard D., M.P., 1, India Buildings, Liverpool.

1898 Johnstone, James, B.Sc., University, Liverpool.

1894 Lea, Rev. T. S., M.A., The Vicarage, St. Austell, Cornwall.

1896 Laverock, W. S., M.A., B.Sc., Free Museums, Liverpool.

1906 Laurie, R. Douglas, M.A., University, Liverpool.

1905 Moore, Prof. B., University, Liverpool.

1904 Newstead, Prof. R., President, M.Sc., A.L.S., School of Tropical Medicine, Liverpool.

1904 O'Connell, Dr. J. H., 38, Heathfield Road Liverpool.

1904 Pallis, Miss M., Tätoi, Aigburth Drive, Liverpool.

1903 Petrie, Sir Charles, Ivy Lodge, Ashfield Road, Aigburth, Liverpool.

1903 Rathbone, H. R., Oakwood, Aigburth.

1890 *Rathbone, Miss May, Backwood, Neston.

1910 Riddell, Wm., M.A., Zoological Department, University, Liverpool.

1909 Roaf, Dr. H. E., The University, Liverpool.
1897 Robinson, H. C., Malay States.
1908 Rock, W. H., 25, Lord Street, Liverpool.
1894 Scott, Andrew, A.L.S., Piel, Barrow-in-Furness.
1908 Share-Jones, John, F.R.C.V.S., University, Liverpool.
1895 Sherrington, Prof., M.D., F.R.S., University, Liverpool.
1886 Smith, Andrew T., 21, Croxteth Road.
1903 Stapledon, W. C., "Annery," Caldy, West Kirby.
1903 Thomas, Dr. Thelwall, 84, Rodney Street, Liverpool.
1905 Thompson, Edwin, 25, Sefton Drive, Liverpool.
1889 Thornely, Miss L. R., Nunclose, Grassendale.
1888 Toll, J. M., 49, Newsham Drive, Liverpool.
1891 Wiglesworth, J., M.D., F.R.C.P., County Asylum, Rainhill.
1909 Whitley, Edward, "Clovelly," Sefton Park.

B. Associate Members.

1905 Carstairs, Miss, 39, Lilley Road, Fairfield.
1905 Harrison, Oulton, Denehurst, Victoria Park, Wavertree.
1910 Kelley, Miss A. M., 10, Percy Street, Liverpool.
1910 Legge, Miss Janet, M.A., Blackburne House, Liverpool.
1903 Tattersall, W. D., D.Sc., The Museum, Manchester.
1910 Tozer, Miss E. N., Physiology Laboratory, The University, Liverpool.

C. University Students' Section.

President: H. G. Jackson, B.Sc.

Hon. Secretaries: C. M. G. Lewis (Miss) and J. E. Hamilton.

Members:

The Misses Jolley, Scott, Gleave, Robinson, Jackson, Latarche, Blackwell, Knight, Edge, Stubbs, Gill, Firan, Robbins, Bamber, Lewis, Kay, E. Smith, Udall, Garside, Little, Higson, Robinson, Clegg, Helby, Rhodes, Upson and Duval; Messrs. Jackson, Daniel, Hamilton, Gelling, Blair and Garas.

D. Honorary Members.

S.A.S., Albert I., Prince de Monaco, 10, Avenue du brocadéro, Paris.

Bornet, Dr. Edouard, Quai de la Tournelle 27, Paris.

Claus, Prof. Carl, University, Vienna.

Fritsch, Prof. Anton, Museum, Prague, Bohemia.

Haeckel, Prof. Dr. E., University, Jena.

Hanitsch, R., Ph.D., Raffles Museum, Singapore.

Solms-Laubach, Prof.-Dr., Botan. Instit., Strassburg.

THE LIVERPOOL BIOLOGICAL SOCIETY.

Dr. In Account with W. J. HALLS, Hon. Treasurer. **Cr.**

1910, Oct. 1st, to Sept. 30th, 1911.	£	s.	d.
To Teas and Attendance at Meetings	2	9	0
,, Messrs. Tinling & Co.	50	4	4
,, Year Book of Scientific Societies	0	7	6
,, Lanternist	0	15	0
,, Hon. Secretary's Expenses	2	6	6
,, Hon. Librarian's Expenses, Postages and Carriage of Volumes	3	10	6
,, Bank Commission	0	1	3
,, Balance	16	13	7
	£76	7	8

1910, Oct. 1st, to Sept. 30th, 1911.	£	s.	d.
By Balance from last Account	31	7	0
,, 18 Subscriptions	18	18	0
,, 3 Associate Members	1	11	6
,, 1 Student Member	0	5	0
,, 3 Entrance Fees	1	11	6
,, 11 Subscriptions in Arrear	11	11	0
,, 4 Subscriptions in Advance	4	4	0
,, Students' Society, for Teas	0	3	6
,, Sale of Volumes	6	10	6
,, Bank Interest	0	5	8
	£76	7	8

Audited and found correct,

HENRY C. BEASLEY.

Liverpool, *October 6th, 1911.*

TRANSACTIONS

OF THE

LIVERPOOL BIOLOGICAL SOCIETY.

INAUGURAL ADDRESS

ON

THE NATURAL HISTORY OF THE MALTESE ISLANDS.

By ROBERT NEWSTEAD, M.Sc., A.L.S., etc., President.

[Abstract.]

The subject matter of the President's Address was gathered during a visit to the Maltese Islands in the summer of 1910, while on a special expedition sent out under the joint auspices of the Colonial Office and the Liverpool School of Tropical Medicine. The object of this expedition was to investigate the problems connected with the menace to health caused by the blood-sucking Papataci-flies of the genus *Phlebotomus*, chiefly among which was the discovery of their breeding places with a view of devising some prophylactic measures for the control of these pests.

The larvae of these flies were found in the crevices beneath loose rock in the caves, and were evidently feeding upon the rejectamenta of the larvae of various insects, *Oniscus* sp., and lizards. Elsewhere they were also discovered in the interior of stone walls. In all of these places, however, the conditions were practically the same, the three main factors being:—(1) the presence of organic matter; (2) moisture, but not in excess; and (3) the absence of light.

The President also made reference to other groups forming the invertebrate fauna of the Islands, more especially so to the orders Hymenoptera and Lepidoptera, pointing out that the representatives of the latter, with few exceptions, were all common to the British Isles; on the other hand, the Hymenoptera were distinctly related to the African forms, of which the genus *Xylocopa* may be taken as an example. The birds, with one or two exceptions, were also distinctly European, and nearly all the species were represented in the British Isles.

THE

MARINE BIOLOGICAL STATION AT PORT ERIN,

BEING THE

TWENTY-FOURTH ANNUAL REPORT

OF THE

LIVERPOOL MARINE BIOLOGY COMMITTEE.

Fortunately, this year there are no losses on the Committee and no changes in the staff to be recorded, but both the Station buildings and their equipment and the scientific and economic work carried out at Port Erin have undergone additions and advances during recent months.

A new research wing, full details of which will be given below, has this autumn been added on to the back of the eastern or laboratory end of the Station. The Liverpool Marine Biology Committee are very much indebted to His Honour the Deemster Callow for his kind offices in obtaining the necessary permission from the Isle of Man Fishery Board (of which he is the Chairman), and from His Excellency the Lieutenant-Governor, to erect the new building on a portion of the Harbour Board land enclosed by the Station boundary wall. Deemster Callow has further been successful in obtaining a new lease of the whole site from the Harbour Board, to run for twenty-one years from the present time, and for that period the new wing now added will be included along with the older buildings in the existing agreement between the Fishery Board on the one hand and the Liverpool Marine Biology Committee on the other. It may not be out of place to record here that throughout these negotiations the various Authorities in the Isle of Man have been most cordial and helpful. I think all sides concerned are satisfied, and that it is now recognised that we are all working together in the public interests and doing our best to advance the science of Marine Biology and a rational investigation of the fishing industries.

Fig. 1. The Biological Station and Fish Hatchery at Port Erin as it was before the new research wing was added at the left-hand end. [From a photo. by Edwin Thompson.

A new departure has been made this summer in holding for the first time at Port Erin, in August, a course of lectures, demonstrations and practical work dealing with Oceanography—the most recent of sciences and one to which a magnificent monument has just been erected in the Museum of Oceanography at Monaco. This institution, built and dedicated to scientific research by S. A. S. Albert I, Prince of Monaco, is devoted wholly to the collection and exposition of all that can be found out as to the oceans of the world and their inhabitants. The Prince of Monaco has been known to men of science for the last quarter century as an ardent explorer who, in his fine ocean yacht "Princesse Alice" (built at

Birkenhead), has added greatly to the exact knowledge of both the physical and the biological conditions of the North Atlantic. The museum which he has now established at Monaco was inaugurated early in April by such an assembly of scientific men interested in the sea as has probably never before been gathered together. Official representatives of France, Germany, Spain, Portugal, Russia and other powers, delegates from all the leading academies of the world, along with many other scientific men invited personally by the Prince, and including such leading authorities as Hensen and Brandt of Kiel, Haeckel of Jena, Pettersson of Stockholm, Grassi of Rome, Perrier and Delage from Paris, Salensky from St. Petersburg, and many others, were united in celebrating the progress of Oceanography and in launching an institution unique in character and of first-rate importance for science.

Oceanography—the science of the sea—has for its scope the determination of the physical, chemical, and biological characters of the oceans of the world, and of the causes of those great seasonal variations in the microscopic living contents upon which depend man's supply of food from the sea, and the continuance of many human industries. There are scarcely any more widespread phenomena in nature, and probably none of more importance to man, than those vast periodic changes in the minute organisms of the sea, the causes of which are now being sought by oceanographers both on exploring vessels and in the laboratories of biological stations and universities of all civilised countries.

If this modern science of the sea has now reached such an advanced stage that it can be demonstrated in a museum to the public, it is clearly desirable that it should be taught both theoretically and practically in our Universities and at Biological Stations. There must be many young biologists and other teachers who desire to learn something of the methods of investigation and the results obtained, by direct contact with the material and the apparatus at some institution where oceanographical research is now being carried on. It was considerations such as these that caused us to arrange, this summer, our first Oceanography course at Port Erin, some of the details of which are given further on in this report.

The usual Easter Vacation Class in Marine Biology as a branch of Nature Study was held with the usual success during the last fortnight in April, and was attended by about twenty senior students of Zoology from the University of Liverpool (see fig. 2). It will be repeated in April, 1911, under the charge of Mr. Douglas Laurie and Dr. Dakin.

In addition, Professor Harvey Gibson proposes during the Easter vacation to arrange a course of lectures and practical work on the collection, identification and distribution of the Marine Algæ of the neighbourhood. The course will occupy one week, beginning on a date to be announced later.

University College, Reading, and the Bedford College for Women, London, have both become subscribing colleges in order to secure a work-place for their biological staff and students; and both colleges have already been represented by workers at the Station.

Professor F. J. Cole, of University College, Reading, who brought three of his senior students to Port Erin for a fortnight in the Easter vacation, writes as follows of the visit:—

"Our stay at Port Erin was a great success, and the students have had a most profitable and pleasant time. I don't think they will readily forget the pleasure of collecting and examining animals alive. I hope to organise the party on a much bigger scale next year, and shall endeavour to bring a botanist and a geologist with me. My students did a little at the freshwater and other land flora when we were out together, but I could not help them there, although fortunately they did not need much help. I have given Dr. Keeble and our Principal a description of our work at Port Erin. They

FIG. 2. The Students and Instructors of the Easter Vacation Class, 1910.

are very sympathetic and keen on developing this side of the Biological work, and the former hopes to come in next year in a way he was not able to do this."

Our three Universities, Manchester, Birmingham, and Liverpool have all been well represented by workers; and in addition a few students from Cambridge, London, and elsewhere have occupied "Tables."

As on previous occasions, Mr. Chadwick has supplied a "Curator's Report," which will be found below, and he has also, as usual, supplied me with details for some other parts of this report.

The Station Record.

Fifty-seven researchers and students have occupied the Work-Tables in the Laboratories for varying periods during the year, as follows:—

Dec. 27th to Jan. 7th	Professor Herdman.—Official.
March 24th to April 7th	Miss Purves.—General.
March 24th to April 7th.	Professor F. J. Cole.—Educational.
March 24th to April 9th.	Miss Millard.—General.
,,	Miss Eales.—General.
,,	Miss Attride.—General.
March 26th to April 11th.	Mr. Phillips.—General.
,, ,,	Mr. Seddon.—General.
March 29th to April 12th.	Mr. W. Tattersall.—Embryology of Littorina.
March 29th to April 27th.	Mr. Wm. Riddell.—Plankton.
March 30th to April 19th.	Dr. J. Stuart Thomson.—Alcyonaria.
April 4th to 11th.	Dr. W. J. Dakin.—Buccinum.
April 4th to 16th.	Mr. G. Storey.—General.
,,	Mr. C. B. Williams.—General.
April 4th to 18th.	Mr. Jackson.—General.
April 6th to 18th.	Dr. Henderson.—Embryology of Littorina, &c.
April 6th to 27th.	Professor Herdman.—Plankton.
April 9th to 26th.	Mr. S. Pugmire.—General.
,,	Mr. Billington.—Algæ.
,,	Mr. W. A. Gunn.—Methods.
April 12th to 26th.	Dr. J. Pearson.—Educational.
,,	Mr. R. D. Laurie.—Educational.

Miss Blackwell.	Miss Horsman.	Miss Lennon.
Miss Bland.	Miss Jackson.	Miss McCaig.
Miss Coburn.	Miss Jolley.	Miss Robinson.
Miss Dixon.	Miss Latarche.	Miss Scott.
Miss Gleave.	Miss Lawson.	Miss Uttley.
Miss Heap.	Miss Lee.	Miss Wildman.

July 4th to 12th.	Mr. Holden.—Marine Algæ.
July 6th to 16th.	Mr. Stirrup.—General.
July 13th to August 18th.	Dr. H. E. Roaf.—Physiology of Invertebrates.
July 21st to August 19th.	Mr. Fuchs.—General.
,, ,,	Mr. Andrews.—Oceanography and General.
August 2nd to 30th.	Dr. Dakin.—Plankton and Buccinum.
August 3rd to 18th.	Mr. Hara.—Oceanography.
,,	Mr. J. Ritchie.—Oceanography.
August 3rd to *20th.*	Mr. Burfield.—Oceanography and General.
August 3rd to Sept. 21st.	Mr. Riddell.—Plankton and Polychæta.
August 4th to Sept. 19th.	Professor Herdman.-Plankton and Educational.
August 4th to 16th.	Miss Stewart.—Oceanography.
,,	Miss Drummond.—Oceanography.

August 4th to 25th.	Miss Jones.—Oceanography and General.
,,	Miss Gibson.—Oceanography and General.
August (occasional visits).	Miss Duffy.—Turbellaria.
Aug. and Sept. (occasional visits).	Mr. C. Okell.—General.
Sept. 3rd to 10th.	Mr. Southwell.—General.
Sept. 4th to 17th.	Mr. W. A. Gunn.—General.
Sept. 8th to Oct. 3rd.	Miss Pixell.—Physiology.
Sept. 8th and 9th.	Professor F. R. Lillie.—General Inspection.
Sept. 14th to 20th.	Dr. Dakin.—Buccinum.
Oct. 8th to 10th.	Professor Herdman.—Official.
,,	Mr. Edwin Thompson.—Official.
Oct. 11th to Nov.	Dr. J. Stuart Thomson.—Alyconaria.

The "Tables" in the Laboratory were occupied as follows:—

Liverpool University Table:—

Professor Herdman.
Dr. Roaf.
Dr. Pearson.
Mr. Laurie.
Mr. Gunn.
Dr. Dakin.
Mr. Billington.
Mr. Jackson.
Miss McCaig.

Liverpool Marine Biology Committee Table:—

Mr. Riddell.
Dr. J. Stuart Thomson.
Mr. Storey.
Mr. Williams.
Mr. Fuchs.
Mr. Andrews.
Mr. Burfield.
Mr. Southwell.
Mr. Ritchie.
Mr. E. Thompson.

Manchester University Table:—

Dr. Henderson.
Mr. Tattersall.
Miss Duffy.
Mr. Phillips.
Mr. Seddon.

Birmingham University Table:—

Miss Purves.
Mr. Stirrup.

University College, Reading, Table:—

Professor Cole.
Miss Millard.
Miss Eales.
Miss Attride.

Bedford College for Women, London, Table:—

Miss Pixell.

The following senior students of Liverpool University occupied the Junior Laboratory for a fortnight during the Easter vacation, and worked together under the supervision of Professor Herdman, Dr. Pearson, and Mr. Laurie:—

Miss Blackwell.
Miss Bland.
Miss Coburn.
Miss Dixon.
Miss Gleave.
Miss Heap.
Miss Horsman.
Miss Jackson.
Miss Jolley.
Miss Latarche.
Miss Lawson.
Miss Lee.
Miss Lennon.
Miss Robinson.
Miss Scott.
Miss Uttley.
Miss Wildman.
Mr. S. Pugmire.

A course of lectures and demonstrations on Oceanography, conducted during the first fortnight in August by Professor Herdman, Dr. Roaf, and Dr. Dakin, was attended by the following students:—

Miss Drummond (Edinburgh).	Mr. Hara (Japan and Berlin).
Miss Gibson (Cardiff).	Mr. Ritchie (Edinburgh).
Miss Jones (Cardiff).	Mr. Burfield (Cambridge).
Miss Stewart (Edinburgh).	Mr. Andrews (Cambridge).

Curator's Report.

Mr. Chadwick reports as follows:—

"It is very gratifying to be able to report a still further increase, during the past year, in the number of researchers and students who have resorted to our laboratories. Representatives of the Universities of Cambridge, Liverpool, Manchester, Birmingham, and Belfast, the University College of Reading, the Bedford College for Women, London, the Royal Scottish Museum, Edinburgh, the 'Challenger' Expedition Office, and several other institutions numbered altogether fifty-seven workers, no less than thirty-nine of whom occupied the laboratories during the Easter vacation, when tables were at a premium, and inconvenience was made tolerable only by the prevailing good fellowship. The Marine Plankton work has been carried on with almost complete regularity, three gatherings, including a vertical haul near the buoy that marks the entrance to the bay and one each with the fine and the coarse nets respectively, over the prescribed course in the bay, having been taken twice a week throughout the year. So much of the Curator's time has been claimed by other work that he has not been able to take more than a small share of estimation and qualitative analysis of the samples.

"The number of visitors to the Aquarium during the year was 12,950. This again shows some falling off;

due, in all probability, to the very unfavourable weather experienced in the Isle of Man during the latter halves of July and August. The number of Guides sold—644—is substantially larger than that of last year. A new edition of the Guide will probably be required in the course of next year.

"A party of thirty members of the Royal Irish Society of Antiquaries, while making a tour of the antiquities of the Island, visited the Station on July 9th, under the leadership of His Honour the Deemster Callow, Chairman of the Isle of Man Fisheries Board. In the absence of Professor Herdman they were received and conducted over the building and its surroundings by the Curator.

"Several large parties of pupils from the local elementary schools, and one party from a Douglas school, all under the guidance of teachers, visited the Station during the autumn. The Curator was in attendance on each occasion, and spent some time in describing the structure and habits of the living occupants of the Aquarium tanks.

"The fauna of the Aquarium tanks undergoes little change from year to year. Amongst the organisms which have made their appearance therein spontaneously during the past year, the Anemone *Corynactis viridis* and the tubicolous Polychaets *Myxicola infundibulum* and *Potamilla reniformis* may be mentioned. Numbers of the last-named have colonised all the table tanks occupied by Anemones. One end of the floor of the conger tank is at present inhabited by quite an extensive forest of the Scyphistoma stage of *Aurelia aurita*.

"An exceptionally fine specimen of the plumose Anemone, *Metridium dianthus*, obtained from the breakwater early in the summer and still living, measures

8 inches in height and 7 inches across the fully expanded tentacles. On one occasion it moved imperceptibly a distance of nearly three feet in twenty-four hours. A number of specimens of *Antedon bifida* have been kept in good health since the end of May in a large tank, the water in which has been changed about twice a week.

"The operations of the Fish Hatchery resulted in the liberation of upwards of eight millions of plaice larvæ and over five thousand lobster larvæ. These figures indicate a substantial advance upon the work of any previous year. Some exceptionally low temperatures of the water in the spawning pond were recorded in January, the Fahrenheit thermometer registering 17° on the 25th and 26th. No consequent injury appears to have been done to the large stock of adult plaice beyond a slight retardation of the spawning season, and this was probably emphasised by the extraordinary severity of the weather in February. As will be seen from the subjoined figures some very large collections of eggs were frequently made during the spawning season.

"With regard to lobster culture it may be said that, though the results have still not attained any magnitude, a distinct step in advance has been made during the season, both as regards the number of larvæ hatched and set free in the sea and the possibility of rearing large numbers in the future. Further experiments with the wooden tank mentioned in last year's Report yielded only negative results, though the propeller apparatus provided by Mr. Ashburner worked satisfactorily on the whole and kept the water in the tank in constant motion. At the beginning of July a number of lobster larvæ in the first stage escaped by some mischance from one of the hatching boxes and were carried by the waste water into the spawning pond. Here they passed normally through the later larval stages, and became lobsterlings. Why other larvæ exposed to the same conditions, except that they were confined to the limits of the experimental tank, should have died remains unexplained. Only six berried lobsters with nearly ripe eggs were brought in by local fishermen during the hatching season. These yielded a total of 5,300 larvæ, of which 600 were the subjects of experiment in the rearing tank, while the remainder were set free in suitable sheltered spots, chiefly within the limits of Port Erin Bay.

"The numbers of plaice eggs collected and of larvæ set free during the past season were as follows:—

Eggs collected.		Date.	Larvæ set free.		Date.
69,800	...	February 19 to 28	48,800	...	March 21
14,700	...	March 1	6,300	...	,, 24
117,000	...	March 5 and 7	98,000	...	,, 26
108,000	...	,, 8	97,500	...	,, 28
400,000	...	,, 12 and 14	318,500	...	April 1
362,300	...	,, 15 and 16	301,300	...	,, 7
842,000	...	,, 18 to 21	677,000	...	,, 8
647,000	...	,, 22 and 23	545,000	...	,, 11
820,000	...	,, 24 and 26	673,000	...	,, 13
760,500	...	,, 28 and 29	559,500	...	,, 15
813,700	...	,, 30 to April 1	597,500	...	,, 18
413,000	...	April 2	297,000	...	,, 20
549,500	...	,, 4 and 5	407,000	...	,, 21
1,220,500	...	,, 6 to 8	760,700	...	,, 25
708,700	...	,, 9 and 11	483,700	...	,, 27
884,000	...	,, 12 and 13	608,500	...	,, 30
738,000	...	,, 14 to 16	500,000	...	May 3
1,191,700	...	,, 18 to 22	704,000	...	,, 9
158,600	...	,, 23	100,000	...	,, 13
678,000	...	,, 25 to 30	327,000	...	,, 16
84,000	...	May 9	5,000	...	,, 23
11,581,000			8,115,300		

"In previous reports attention has been called to the occurrence of large numbers of the ephyra stage of *Aurelia aurita* in the spawning pond during the winter months. This organism again occurred in January and February of the present year, but in greatly reduced numbers. Its numerical position was taken by the ephyra of another species of Medusa, probably *Cyanea capillata*, which was very abundant until the end of February. The Anthomedusa *Margellium octopunctatum* also occurred in enormous numbers at the same time. In many of these, three generations could be seen. Plankton organisms were abundant in the pond during the summer and autumn months, and in a good light the lobster larvæ could be seen pursuing and feeding upon them."

Description of the New Buildings.

The new Research wing, measuring 44ft. by 18ft. and two storeys high, runs southwards towards the cliff, at right angles with the main building, which it joins at the eastward or laboratory end (see fig. 3). It is built of the same local stone and in the same plain substantial style as the older part of the institution. It was commenced in September, and finished in December, 1910, and will be furnished ready for workers by the Easter vacation, 1911. On each storey there is communication with the old building—on the ground floor by means of the former back laboratory door, and on the upper floor by means of a transformed laboratory window. Each floor also opens into the back yard, the upper one by means of an outside stair.

The ground floor contains a photographic dark-room, a store-room for chemicals, apparatus, and glass-ware, a

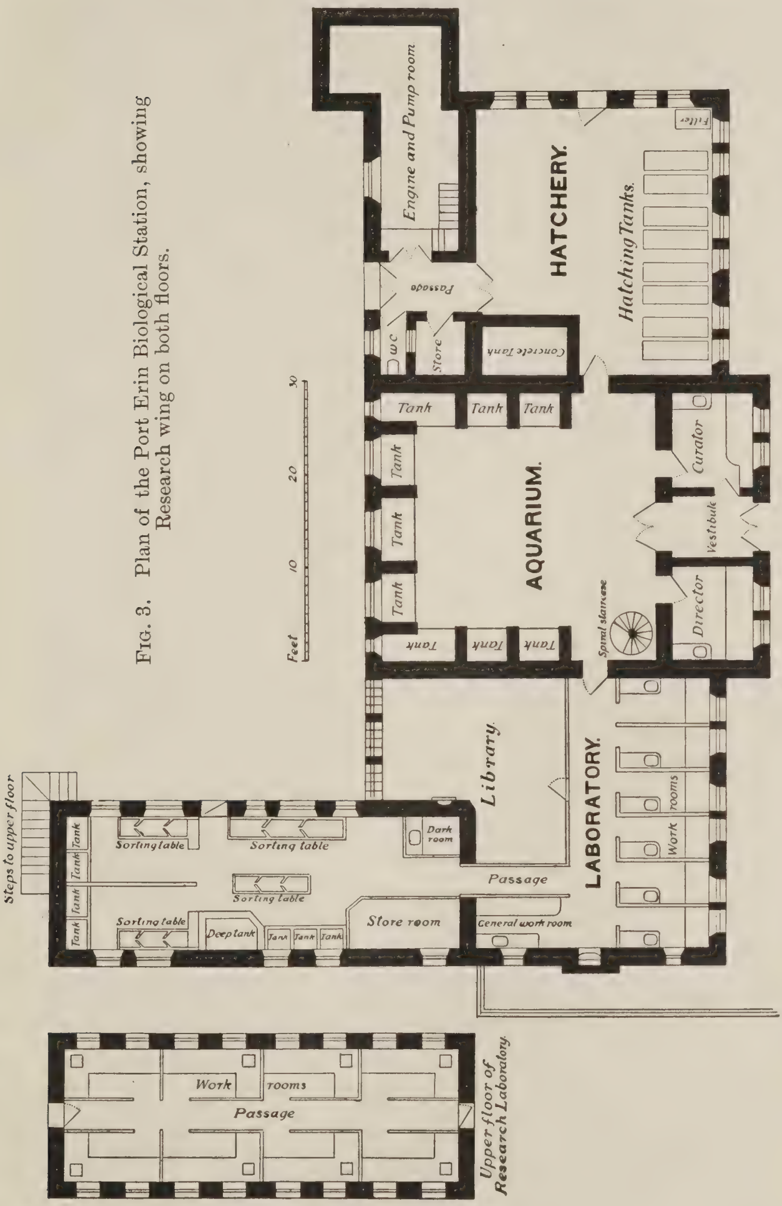


FIG. 3. Plan of the Port Erin Biological Station, showing Research wing on both floors.

large researchers' tank room, and two smaller tank rooms* at the far end, one for investigators in bio-chemistry or comparative physiology, and the other for embryological work. All three tank rooms have cemented floors and walls, and are well provided with concrete tanks of different depths, and with abundance of sea-water taps.

In the large room, common to all workers, there is a deep concrete tank after the style of the lobster tank in the Hatchery, which will be suitable for keeping fishes or any large crustaceans and molluscs that are under investigation or require to be stored. Along the same wall there is also a range of three smaller shallow tanks, varying from six inches to a foot in depth, and about three feet square superficially. Each of these is provided with a separate sea-water tap and waste-pipe, but they can, if necessary, be connected up in series if it is desired that the same water should run through any two or more. In each of the smaller rooms for physiology and embryology there are two similar shallow concrete tanks occupying the end wall. Both in the large room and in each smaller room in front of the windows there are concrete platforms, about three feet high, with cemented tops excavated to a depth of from two to four inches, which can be used either as sorting tables or as a series of very shallow tanks. They are abundantly supplied with sea-water taps, and have certain transverse parti-

*Such a separate small experimental tank-room would be convenient for two or three workers engaged on a joint investigation—such as the research undertaken in the spring of 1905 at Port Erin by Professor B. Moore, Dr. H. E. Roaf and Mr. Edward Whitley on the effect of treating Echinus eggs and early embryos with various dilute alkaline and acid solutions added to the sea-water (see this Report for 1905, p. 28, and *Proc. Roy. Soc., B.*, Vol. LXXVII., p. 102, 1906). The results obtained at that time by Professor Moore and his fellow-workers showed that the addition of small quantities of alkali increased the rate of cell-reproduction and caused the mitotic division to become irregular—results which have formed the starting point for some recent lines of investigation into the cause of cancer.

tions (see fig. 3), with openings which can be blocked so as to regulate the flow of a trickle of water, or so as to retain a shallow pool. The largest of these sorting tables, about 12 feet in length, is placed in front of a range of eight windows, and will no doubt be most useful for the examination and classification of the minuter animals brought in with sea-weed, zoophytes, and other more bulky material from collecting expeditions.

The sorting tables in the two smaller tank rooms will no doubt be more frequently used either as shallow experimental tanks or as benches upon which smaller aquaria can be placed in series and supplied with running water. Over a central sorting table of the same nature in the middle of the floor of the larger tank room it is proposed to erect an apparatus for communicating motion by means of the "plunger" device or otherwise to the water in any aquaria that may be placed below.

The upper floor (see fig. 3), which may be entered either from the students' laboratory of the old building, or from an outside flight of concrete steps leading to a door at the south end, is divided by wooden partitions into a central passage and a series of eight separate research rooms. Each research room has two windows, about thirteen feet of working bench and a sink supplied with both fresh and salt water. The intention is that each such workroom should be assigned to one researcher who is working alone, but there is obviously abundance of room for two senior students working in company, or for a pair of collaborators engaged in the same research.

The addition of this research wing has enabled us to effect a much-needed improvement in the library on the ground floor of the old building. The former dark room and store-room, which were only separated off by wooden partitions, have been thrown into the library, and the outer wall of the latter has been removed to a new position, as may be seen on the plan (fig. 3), so as to increase the room to about three times its original size. The room now measures about 18 feet in length by 20 feet from window to door. It is at present larger than is necessary for the accommodation of our small working library of Marine Biological and Fisheries publications, but will no doubt be a most useful sitting-room common to all workers in the building for purposes of reading, writing and occasional meetings. The new buildings are certainly a most notable addition to the resources of the institution, and will doubtless be appreciated by many workers in the future. We are very grateful to those who kindly provided the funds that made this new laboratory wing possible (see Hon. Treasurer's Statement at the conclusion of this Report).

Some Other Investigations.

Mr. William Riddell, in addition to assisting me in my Plankton investigation, has been collecting and identifying the Polychaet Annelids of the neighbourhood, and he reports to me on his work as follows:—

"I am able to add twenty-eight species of Polychaeta to the previous records for Port Erin, sixteen being apparently new to the L.M.B.C. district. Four of these had been identified by Mr. Chadwick but not recorded, and three of these I only know from his specimens. I am able to confirm the previous records of *Sthenelais zetlandica*, which Hornell has doubted, as I have found a mounted parapodium, from the original specimen, in the Zoological Department of the University of Liverpool. At the same time I am inclined to doubt one or two of Hornell's records, notably *Scolelepis (Nerine) vulgaris* Johnst., which I think should be *S. fuliginosa* Cpde. At least, all specimens I have been able to find have belonged to the latter species.

"I have no doubt that a number of other species could easily be added to the list by further faunistic work. Sixteen of my present records are the result of three dredging expeditions from the "Ladybird," nine of these being new to the L.M.B.C. district. The new records are as follows, those marked with an asterisk being new to the L.M.B.C. district:—*Syllis armillaris*, **S. cornuta*, **S. krohnii*, **Trypanosyllis zebra*, *Castalia punctata*, **Magalia perarmata*, *Phyllodoce maculata*, **Eumida sanguinea*, *Eunice harassi*, **Ophryotrocha puerilis*, **Glycera lapidum*, *G. goësi*, *Goniada maculata*, *Ephesia gracilis*, **Aricia cuvieri*, **Scolelepis fuliginosa*, **Polydora flava*, **Dodecaceria concharum*, **Melinna cristata*, *Pectinaria auricoma*, *Flabelligera affinis*, *Dasychone herdmani*, **Potamilla reniformis*, **Myxicola infundibulum*, **Amphiglena mediterranea*, *Serpula reversa*, *Spirorbis lucidus*, and **Salmacina dysteri*."

Mr. W. M. Tattersall, M.Sc., reports to me as follows:—"From March 29th to April 11th I occupied the Manchester University 'Table.' My object was to study the development of the periwinkle, *Littorina littorea*, and to preserve for microscopical examination as many stages as could be obtained. I regret to say that my efforts were unsuccessful. I was able to obtain fertilised eggs without any trouble, but the greatest difficulty was experienced in rearing them. At present I am unable to account for the failure, but I can say that it was not due to the presence and rapid multiplication of Infusoria and other Protozoa, such as had on previous occasions proved a source of trouble. I intend on some future occasion to continue the work, and to modify somewhat my treatment of the eggs, in the hope that greater success may result. My thanks are due to the Council of the Manchester University for the use of their Work-Table, and to Professor Herdman and Mr. Chadwick for the facilities granted to me at the Biological Station, and for their assistance and advice in the work I had on hand."

Dr. H. E. Roaf made some further observations on the hypobranchial gland of *Purpura lapillus*, and reports as follows:—

"Sections of material fixed in various bichromate solutions show a brown stained substance in the region of the purple-forming area. Now vertebrate tissues which contain 'adrenalin-like' substances stain brown with bichromate fixatives. As previous chemical and physiological tests* had shown an 'adrenalin-like' substance in the same region of the mantle where the brown stained material has now been found, it appears that the active substance is formed in the purple-producing area. It is hoped that the results will be ready for publication before the end of the year."

Dr. W. J. Dakin, who occupied the Liverpool University Work-Table, reports to me as follows in regard to his results:—

"During the Easter vacation my time was spent chiefly in connection with some experiments to determine the osmotic pressure of the contents of plaice eggs and larvæ. The results of this investigation, which was supplemented by observations on dog-fish eggs, have been communicated to the British Association, at the Sheffield meeting, and will be published in full in the next number of the 'Internationale Revue d. Hydrobiologie.' This

* M. Nierenstein and H. E. Roaf, Journ. Physiol., Vol. XXXVI, Proceedings, p. v; and C.-R. Soc. de Biol., Vol. LXIII, p. 773, 1907.

research could not have been carried out at any biological station which did not possess a fish hatchery, and there are many other problems in connection with the biology of fish larvæ which could be undertaken with advantage at Port Erin.

"During the Easter vacation I fixed a considerable quantity of whelk material for histological purposes, in connection with the L.M.B.C. Memoir, 'Buccinum,' on which I am now engaged; and whilst cutting out the renal organs of certain specimens, I noticed numerous exceedingly small white bodies. Sections through the renal organ, made on my return to Belfast, showed that these bodies were Sporozoa, and apparently an unknown species. I have now been able to make out from this material a considerable number of the stages in the life history, and hope to publish a preliminary statement at an early date. The parasite is of considerable size when full grown, and is, in all probability, a Coccidian."

Dr. W. D. Henderson, now Head of the Zoology Department in the University of Bristol, while occupying the Manchester University Work-Table in April was engaged in a research on the development of the head in the Plaice. Dr. Henderson reports to me that the work is not completed, but that his material promises to furnish some interesting results, and that he proposes to communicate the finished work to the Royal Society of Edinburgh.

Mr. Andrew Scott reports that several additions to the local fauna have come into his hands during the year, and one of the most interesting of these is the curious little burrowing Crustacean, *Callianassa subterranea*, which is intermediate between the hermit crabs and the lobsters. A freshly severed chela or great claw, which must have been recently eaten, was found in the stomach of a common dragonet, a local fish trawled to the West of the Morecambe Bay Light Ship in February.

Mr. Scott, from the examination of the Port Erin tow-nettings, finds that there has been this year a quite unusual invasion of the Manx waters by *Noctiluca miliaris,* the minute and lowly organism which is responsible for much of the summer luminosity of the sea on the coasts of Wales and Lancashire. It appeared in quantity in our bay collections at the end of July, and then again in September.

Oceanography Course.

The credit for this idea is due mainly to Dr. W. J. Dakin, who first suggested to me that such a course ought to be wanted by senior students of Marine Biology and by young scientific men and women holding posts, and might well, with the apparatus and other facilities we now possess, be held at Port Erin. We invited Dr. Roaf to join us in order to introduce the Comparative Physiology of lower animals, and some other Bio-chemical considerations. The course was advertised in the following terms:

"Port Erin Biological Station.

"If a sufficient number of applications are received, a short Vacation Course on

OCEANOGRAPHY

(Hydrography and Planktology)

will be given at Port Erin, Isle of Man, in the first half of August, by Professor W. A. Herdman, F.R.S., Dr. W. J. Dakin, and Dr. H. E. Roaf.

"The course will consist partly of lectures and laboratory work in the Biological Station, and partly of investigations at sea and on the shore—occasionally on

Professor Herdman's yacht, which is provided with the necessary oceanographic apparatus. Applications or enquiries should be sent, etc."

The course was eventually attended by eight persons, of whom one-half may be regarded as senior students or young graduates, and the other half as being in the category of holding scientific posts.

Fig. 4. The first Oceanography Class at Port Erin, August, 1910.
[From a photo. by H. E. Roaf.

The work started on most days with a lecture at ten o'clock, followed by laboratory work. In the afternoon there was occasionally a second lecture, but more usually a collecting expedition on the shore or at sea was arranged, or demonstrations of the planktonic and the hydrographic apparatus, and on the methods of microscopic examination and estimation of plankton samples, were given either in the laboratory or on the yacht.

A couple of lectures, at the beginning of the course, on the history and methods and the problems and difficulties of Oceanography, and one at the conclusion on its applications to sea-fisheries research, were given by Professor Herdman, who also conducted some of the shore and sea expeditions. The rest of the work, lectures and demonstrations and detailed laboratory practice, was carried on separately or jointly by Dr. Dakin and Dr. Roaf. If there is any demand for it this course will probably be repeated next summer. It may be of interest to insert here as a record a photograph (fig. 4) of the students and instructors of our first Oceanography Class.

It may be useful, as this was a pioneer course of a somewhat experimental nature, to put on record the following additional details of the work that was actually carried out. The programme was as follows:—

Thursday—	Introductory lecture on the history and nature of Oceanography (Professor Herdman). Lecture on Chemistry of Sea-water (Dr. Roaf). Demonstration on Hydrographic Instruments (Dr. Dakin).
Friday—	10 a.m. Lecture on Salinities and Temperatures of the Sea (Dr. Dakin). Followed by practical work in the Laboratory. Afternoon. Collecting Expedition to the limestone reefs at Port St. Mary.
Saturday—	10 a.m. Lecture on methods of Oceanography (Professor Herdman). Followed by Laboratory work.
Monday—	10 a.m. Lecture and Demonstration on Plankton quantitative and other nets (Dr. Dakin). Followed by inspection and practice with apparatus on the Yacht. Collecting Expedition on the Shore in the Afternoon and Evening.
Tuesday—	9 a.m. Expedition on Fishery Steamer, to see trawling, plankton and hydrographic work. Afternoon. Work in Laboratory.
Wednesday—	Morning. Plankton Expedition on S.Y. "Ladybird." 3 p.m. Lecture on Gases and Alkalinity of Sea-water (Dr. Roaf).

Thursday—	10 a.m. Lecture on Quantitative Methods in Planktology (Dr. Dakin). Afternoon. Dredging Expedition on S.Y. "Ladybird."
Friday—	10 a.m. Lecture and Demonstration on Comparative Physiology of Marine Invertebrata (Dr. Roaf).
Saturday—	Morning. Lecture on the Sea as a Nutrient Fluid, etc. (Dr. Dakin). Followed by Plankton work in the Laboratory.
Monday—	Morning. Lecture on Oceanography and the Fisheries (Professor Herdman). Followed by Plankton work in the Laboratory.
Tuesday—	Morning. Plankton work in the Laboratory. Afternoon. Dredging Expedition.
Wednesday—	Morning. Plankton work in the Laboratory. Examination of literature of the subject.

The apparatus and methods employed in the actual enumeration of plankton organisms were demonstrated by Dr. Dakin. The microscope used, which has proved exceedingly efficient, is one of the new Leitz' stands which allows room on the stage for a somewhat large plate. The largest mechanical stage made by the same makers gives more than enough play. Glass counting plates have been obtained from Zwickerts of Kiel, and these with Hensen's "Stempel-pipetten" completed the apparatus used for this part of the work. In connection with this side of the biological work, the defects and inaccuracies of quantitative plankton studies were treated in detail, and the object of the rather monotonous series of counts was explained. Dr. Dakin hopes next summer to be able to compare some of the results obtained during a quantitative examination of the freshwater plankton of Lough Neagh, in Ireland, with those obtained in the Irish Sea during past years.

Another subject which was treated in our course at Port Erin, and which opens up an interesting field for future research, is the question of the food of marine animals. The credit of drawing the attention of Zoologists to this important subject—important from the purely scientific as well as from an economic point of view—belongs to the physiologist Pütter. It seems probable that in many cases organic compounds in solution in sea water are utilised by marine animals as food in addition to solid matter. In the present course, however, it was maintained that further experiments are required to determine the relative amounts of food present in solution and as plankton in definite volumes of sea-water taken at different seasons. The amount of carbon in solution has been determined so far by direct analysis of filtered sea-water, whereas the quantity present as plankton has been determined by calculations from analyses of plankton catches. It should be quite simple to determine, by taking filtered and non-filtered samples of sea-water at the same time and place, and by carrying out direct analyses of these, whether the organic carbon compounds in solution are a more abundant source of carbon than the planktonic organisms. Dr. Dakin hopes to return to this matter in his future work.

Dr. Roaf supplies the following note on the chemical and physiological part of the course:—

"The chemistry of the sea-water was treated from the modern standpoint of physical chemistry, involving the question of ionisation and equilibria between the various constituents.

"Estimation of chlorides was carried out by Mohr's method as modified by the International Committee, using Knudsen's pipette and burette.

"The oxygen in sea-water was determined by Winkler's method as applied by Natterer.

"Methods for the estimation of carbon-dioxide are numerous, but the necessary steps are as follows:—(1) Liberation of carbonic acid by some stronger acid, (2) raising of the vapour pressure of carbon-dioxide by heat, and (3) lowering the pressure and continuous removal of the gaseous carbon-dioxide. The volume of gaseous carbon-dioxide can be measured and reduced to normal temperature and pressure (C. J. J. Fox), or the gas can be absorbed by barium hydrate. The method followed was the latter, and the precipitated barium carbonate was filtered off, washed, and titrated by standard acid in the presence of di-methyl-amino-azo-benzol.

"The usual method used to determine the alkalinity is cumbersome, as one adds excess of acid, boils for half an hour, and titrates back by barium hydrate in the presence of phenol-phthalein. A much simpler method was used. The sea-water was titrated with N/10 hydrochloric acid in the presence of di-methyl-amino-azo-benzol. The principle is to use an indicator that is not sensitive to such a weak acid as carbonic acid, and hence the excess of bases not combined with strong acids is determined. By using a control of sea-water containing the same amount of indicator and possibly by using a special burette and more dilute acid the delicacy of the reaction can be increased.

"The advantages were a great saving of time, and the errors of two burette readings instead of four. The results showed the same alkalinity as was obtained by the longer method.

"Calcium was determined by precipitation, as oxalate, in the presence of acetic acid. The precipitate was dissolved in dilute hydrochloric acid and reprecipitated by sodium acetate. After washing the precipitate it was titrated by potassium permanganate in the presence of sulphuric acid.

"Under the head of Comparative Physiology, a number of points in connection with the physiology of digestion, respiration, etc., of invertebrates were described and demonstrated, both by experiments in the Laboratory and observation in the Aquarium tanks."

It may be useful to place on record also a list of the oceanographical nets and instruments and other pieces of apparatus that were described and shown in action, either in the laboratory or at sea, during the course:—

Hensen's closing quantitative tow-net (Petersen's modification), No. 20 silk.
Nansen's closing tow-nets (3 sizes, 1 metre, 50 cm., and 35 cm. in diameter), various grades of silk.
Apstein's smaller tow-net, No. 20 silk.
Ordinary horizontal tow-nets of various sizes and patterns, and sizes of mesh.
Large Shear-net (for mid-water work).
Petersen's Yngel-trawl.
Apstein's Plankton-röhre.
Lucas Sounding machine, with 200 fathoms of pianoforte wire.
Metre wheel for measuring the length of line run out.
Ekman's reversing Water-bottle, with thermometers.
Richard (Monaco) Water-bottle.
Pettersson-Nansen Insulated Water-bottle.
Set of Kiel Areometers.
Ekman propeller current meter.
Negretti and Zambra deep-sea reversing thermometer.
Richter's reversing thermometer.
International standard surface thermometers.
Microscope adapted for counting plankton organisms.
Kiel Stempel-pipettes; and other laboratory microscopical accessories.
Burettes and pipettes for chlorine estimations; and other accessories for chemical work.
Dredging derrick, leading blocks, steam capstan, hand winding reel, with 200 fathoms steel wire rope and brake.
Beam trawl, otter fish trawl, Agassiz trawl.
Naturalist's dredges of various sizes and patterns; rope tangles, etc.
Sorting sieves, collecting jars and tubes, fish tins, and other accessories of collecting expeditions.

Plankton Observations.

The dredging, tow-netting and other investigations at sea, started some years ago with the yacht "Ladybird," have been carried on vigorously during the Easter and Summer vacations of 1910. Nearly 650 samples of plankton have been collected this year, with various nets (figs. 5 and 6) in the seas around Port Erin, and have been sent to Mr. Andrew Scott for detailed microscopic investigation. During both the Easter and the Summer vacation Mr. W. Riddell, M.A., of Belfast, again gave me most valuable assistance in taking daily plankton observations from the yacht. Dr. W. J. Dakin during part of the time took charge of the

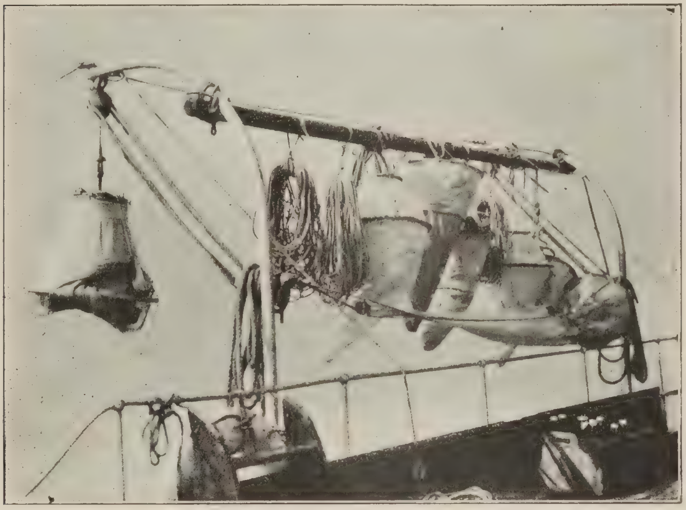


FIG. 5. Set of plankton nets on S.Y. "Ladybird."
[From a photo. by Edwin Thompson.

corresponding Hydrographic work, and Mr. W. Gunn, from the Liverpool Laboratory, also gave efficient help. A detailed account of the results of these observations will be published in the spring in the Annual Report of the Lancashire Sea-Fisheries Investigations. In the meantime, the following record of the spread of a minute, free, lowly plant through European seas from the far East may be of interest.

Biddulphia sinensis is an Indo-Pacific Diatom which was probably introduced accidentally (e.g., by a ship from the East) into European waters near the mouth of the Elbe about September, 1903, and which has apparently spread in various directions from that point. Later in 1903 it made its appearance in the Skagerack;

FIG. 6. Some plankton nets, shear-net, &c., on S.Y. "Ladybiid." The Agassiz trawl is seen in the distance hanging from the derrick.
[From a photo. by R. Okell.

it was shortly afterwards found to be present in quantity in the S.E. part of the North Sea, near Hamburg; from this it spread northwards to the coast of Jutland, and in the following year appeared on the Belgian coast also; in all these regions it became established, and re-appeared year after year. In 1907 it had penetrated to the Baltic, to the North of Scotland, and southwards in the North Sea to the entrance of the English Channel. The Norwegian observers tell us that it made its appearance also in the sea off Bergen in that same year, and more recent reports show that it has continued in all these sea-areas up to the present time, in each year reaching a maximum in November and a minimum about May.

We first noticed it in our bay gatherings at Port

Erin on November 9th, 1909, when 400 specimens were found in one gathering; on November 13th about four times that quantity was present, and during the remainder of the year, to December 17th, numbers varying from 1,000 down to 100 or so were obtained. This year (November, 1910) it has again appeared, and Mr. Scott, who is at present examining the plankton collections made in the bay, writes to me that *Biddulphia sinensis* in the early November collections seems to be more abundant and in much better condition than when it first made its appearance in our district. He says that the cells are seen in active division, and that chains of two and four cells together are quite frequently found. It seems as if this Eastern species, accidentally introduced into European seas, has now established itself as a member of our local plankton.

During a few weeks in the summer (July) of the last four years, in the course of short cruises amongst the islands and sea-lochs of the Hebrides, I have extended our plankton observations of the Irish Sea northwards by taking vertical hauls with the "Nansen" closing net from many of the deepest holes we could discover. I have 33 of these gatherings from over 50 fathoms, and 18 from over 100—the deepest is from 133 fathoms in the Sound of Raasay, N.E. of Skye (see fig. 7).

A preliminary account of the results obtained from these Hebridean hauls, and a comparison with the results of similar work in the Irish Sea at the same time of the year, was given to the Linnean Society of London on November 3rd, 1910, and the detailed report on the organisms obtained in all these gatherings, will be given in the next Lancashire Sea-Fisheries Annual Report.

When we examine these series of Scottish gatherings

FIG. 7. West Coast of Scotland, showing depths of over 50 (shaded) and over 100 (black outline) fathoms. Twenty-five stations at which deep hauls were taken are marked by a small black circle enclosing a cross.

from the same localities in different years, two conclusions become evident:—

1. That localities, in some cases not very far apart, differ very considerably in the nature of their plankton at the same time of year.

2. That there is a constancy year after year in the nature of the plankton at some localities.

A few examples will make this clear:—

1. In the northern area (north of Oban) the hauls taken in Loch Hourn and Loch Nevis, off the Sound of Sleat, are on all occasions very different from those taken off Ardmore in Mull, and from those taken off the Island of Canna; also those taken in the Lynn of Morven at one end of the Sound of Mull differ from those taken between Mull and Ardnamurchan at the opposite end. Again, in the southern area (the Clyde sea-area) the hauls from off Skate Island, in the entrance to Loch Fyne, differ markedly from those taken further south in the Sound of Bute and the Firth of Clyde off Arran.

2. The Loch Fyne vertical hauls are always characterised by the abundance of large Copepoda; the hauls off Canna and elsewhere in the sea of the Hebrides by the prevalence of Diatoms; those in the Firth of Lorn by a fine Zoo-plankton, and those round Raasay, north-east of Skye, by a much coarser Zoo-plankton.

Thus we have evidence that off the north-west coast of Scotland, at one time of year (July) in several successive seasons, the plankton as sampled by vertical hauls was of different types (Zoo- and Phyto-plankton) in different localities, but preserved a constant character in each.

Now in the Irish Sea, around the Isle of Man, when the plankton of the whole year is considered, it is clear that neighbouring localities do not present widely different characters as they do in the Hebrides, and that a Zoo-plankton and a Phyto-plankton do not occur simultaneously a few miles apart. In spring or early summer in the Irish Sea, as elsewhere, there is an enormous Phyto-plankton maximum, which gradually dies away and is replaced by the Zoo-plankton which is characteristic of the summer months. In September or October again Diatoms make their appearance in profusion, constituting a second, autumnal, Phyto-plankton maximum. The accompanying diagram (fig. 8)

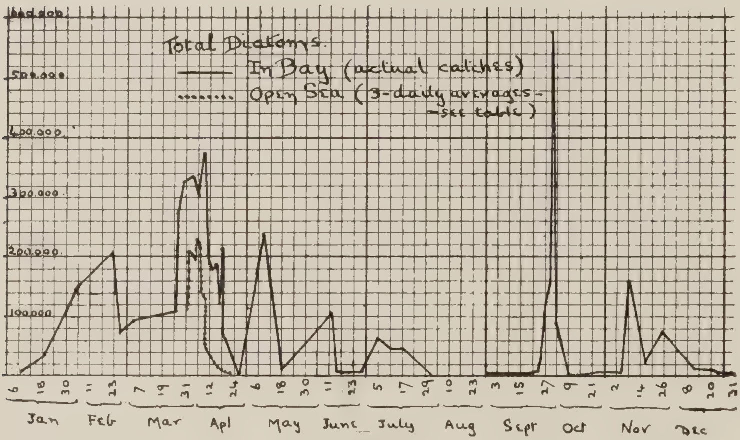


Fig. 8.

shows, *e.g.*, the curve for the total Diatoms in a recent year, as given by a very large series of gatherings, extending over every month, taken across Port Erin Bay. The high points in April and May, and then again, but of less duration, in September and October, show the influence of the vernal and autumnal Phyto-plankton maxima, and the effect would be almost as marked if the curve were drawn to represent the total plankton. Taking the results of the last three years in Port Erin

Bay, we find that the monthly averages (see fig. 9) for the total plankton begin low in January and February, rise in March and still more in April, reach the maximum in May, drop rapidly through June, July and August to the summer minimum, rise a little in September and October to form the autumnal maximum, and fall again in November and December to the mid-winter minimum. The autumnal maximum is always

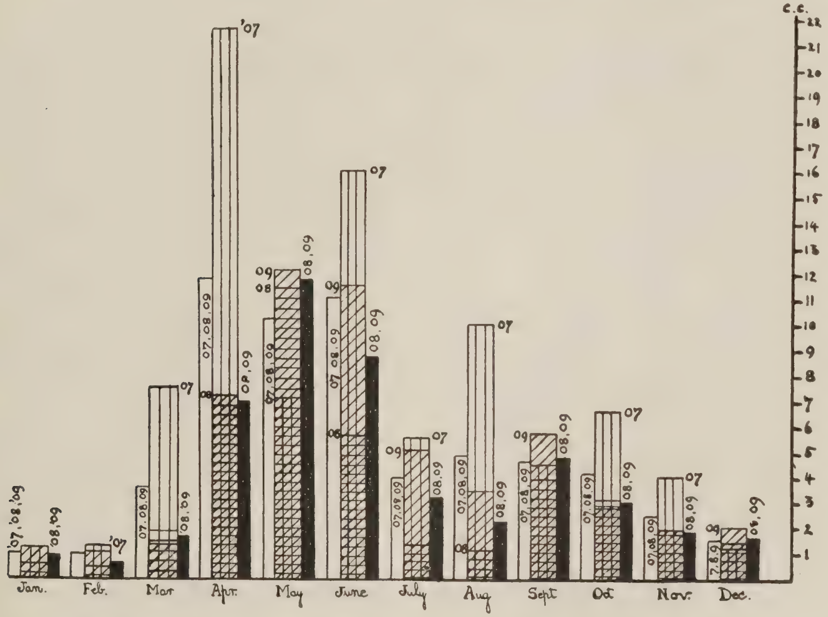


FIG. 9. Diagram of average haul of Plankton per month in the three years (1907-09) separately and combined. The black columns show most clearly the changes throughout the year.

much less than the vernal. Both are caused by a very marked increase in the Phyto-plankton, chiefly Diatoms, and the species which are the most abundant and characteristic at the two seasons are for the most part distinct. In summer when the Phyto-plankton is practically absent, the Zoo-plankton reaches its maximum; but in bulk, even at the maximum, the Zoo-plankton, except on rare occasions, is small compared with the spring gatherings of Phyto-plankton. A Phyto-plankton gathering in the Irish Sea is practically only obtainable in spring or in late autumn; and if the gathering be a very large one, it is certain to have been taken at the former period, say between the middle of March and the middle of May.

FIG. 10.—A Phyto-plankton gathering consisting mainly of Diatoms (*Thalassiosira*).

FIG. 11.—A Zoo-plankton gathering consisting mainly of Copepoda (*Acartia*).

[From photo-micrographs by Edwin Thompson.]

But in the Hebrides, as we have seen, very large Phyto-plankton hauls (fig. 10) may be taken year after year in July—when in the Irish Sea the hauls are for the most part comparatively small, and are all composed of Zoo-plankton (fig. 11). Mr. Andrew Scott, A.L.S., who has been associated with me for some years in studying the plankton of the Irish Sea, remarked when I showed him some of the Phyto-plankton samples from Canna, Rum and Ardmore, "If I had not seen the locality and date on the bottles I should have placed them without doubt as Irish Sea gatherings taken in April." And the resemblance, I may add, is not merely in general appearance, but extends to the microscopic composition. The gatherings from Ardmore, for example, contain abundance of *Chaetoceros contortum* and *C. decipiens*, *Rhizosolenia semispina*, *Lauderia borealis*, *Thalassiosira gravida* and *T. nordenskioldii*—all of them Diatoms that are characteristic of an April gathering in the Irish Sea, off Port Erin. The abundance of the two species of *Thalassiosira* makes this and other July gatherings from round Canna and Mull quite unlike a September Diatom haul in the Irish Sea, as the genus *Thalassiosira*, abundant in the north, is practically absent at the time of the autumnal maximum in the south.

We have probably not yet enough information before us to justify any attempt to explain the remarkable difference between the Hebridean plankton gatherings and those from the Irish Sea in summer. It may be that the great vernal maximum, which dies away in May or June in the Irish Sea, passes off more slowly further north, and is still found lingering on in some parts of the Hebrides until the end of July; or it may be that in some of these deep northern channels the Diatoms, that elsewhere constitute our vernal maximum, remain on in comparative abundance throughout the greater part of the year. A third possible explanation is that the Diatoms constituting these July Phyto-plankton gatherings may have invaded the Hebridean seas from the North Atlantic at some period subsequent to the vernal maximum.

It is clear that this problem in distribution can only be solved by frequent periodic observations carried on throughout the year by means of vertical hauls at fixed localities, and such series of observations have still to be made in the Scottish seas. There is apparently a great gap in our knowledge of the plankton, extending from the North of Scotland to the Irish Sea, which neither the International observations on the one hand, nor those of the Scottish and Irish Fisheries Authorities on the other, seem to fill up. For a complete understanding of the plankton throughout the year in the Irish Sea it is essential that we should have some information as to the planktonic changes month by month on the North coast of Ireland and on the West coast of Scotland, and it is to be hoped that by co-operation between different Fisheries Authorities and private investigators these gaps in our knowledge may before long be satisfactorily filled up.

L.M.B.C. Memoirs.

No further Memoirs since No. XIX, Polychæt Larvæ (the young stages of the Higher Worms) at Port Erin, by Mr. F. H. Gravely, M.Sc., have been published. Buccinum, the large Whelk, by Dr. W. J. Dakin, is nearly ready and will be the next to appear. Doris, the Sea-lemon, by Sir Charles Eliot; Sagitta, the Arrow-worm, by Mr. Harvey; Sabellaria, a tube-building Annelid, by Mr. A. T. Watson, and other Memoirs are also far advanced; and we hope to have a Memoir on our Irish Sea species of Ceratium and other Dinoflagellata from Professor C. A. Kofoid, who did some work on the local material during his visit to our laboratory in 1908. This large amount of excellent material, which the Committee is happy to be able to issue to the scientific world, is, however, embarrassing from the point of view of expense. Lithographic plates, such as most of these Memoirs require, are rather costly, and with the growing elaboration of the subject more detailed illustration is necessary. The Committee are therefore always very grateful for special donations and grants, such as have in the past enabled the Treasurer to meet the expenses of plates for several of the recently issued Memoirs. Further donations to provide for the illustrations of those still unpublished will be very welcome.

The following shows a list of the Memoirs already published or arranged for:—

I. Ascidia, W. A. Herdman, 60 pp., 5 Pls.
II. Cardium, J. Johnstone, 92 pp., 7 Pls.
III. Echinus, H. C. Chadwick, 36 pp., 5 Pls.
IV. Codium, R. J. H. Gibson and H. Auld, 3 Pls.
V. Alcyonium, S. J. Hickson, 30 pp., 3 Pls.
VI. Lepeophtheirus and Lernæa, A. Scott, 5 Pls.
VII. Lineus, R. C. Punnett, 40 pp., 4 Pls.
VIII. Plaice, F. J. Cole and J. Johnstone, 11 Pls.
IX. Chondrus, O. V. Darbishire, 50 pp., 7 Pls.
X. Patella, J. R. A. Davis and H. J. Fleure, 4 Pls.
XI. Arenicola, J. H. Ashworth, 126 pp., 8 Pls.
XII. Gammarus, M. Cussans, 55 pp., 4 Pls.
XIII. Anurida, A. D. Imms, 107 pp., 8 Pls.
XIV. Ligia, C. G. Hewitt, 45 pp., 4 Pls.
XV. Antedon, H. C. Chadwick, 55 pp., 7 Pls.
XVI. Cancer, J. Pearson, 217 pp., 13 Pls.
XVII. Pecten, W. J. Dakin, 144 pp., 9 Pls.
XVIII. Eledone, A. Isgrove, 113 pp., 10 Pls.
XIX. Polychaet Larvæ, F. H. Gravely, 79 pp., 4 Pls.
Buccinum, W. J. Dakin.
Sabellaria, A. T. Watson.
Sagitta, E. J W. Harvey.

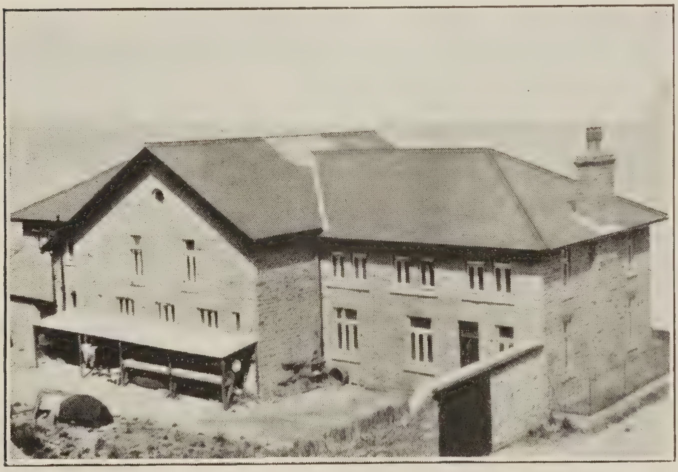
Zostera, Daisy G. Scott.
Doris, Sir Charles Eliot.
Tubularia, James Ritchie.
Cucumaria, E. Hindle.
Oyster, W. A. Herdman and J. T. Jenkins.
Ostracod (Cythere), Andrew Scott.
Bugula, Laura R. Thornely.
Himanthalia, F. J. Lewis.
Diatoms, F. E. Weiss.
Fucus, J. B. Farmer.
Botrylloides, W. A. Herdman.
Actinia, J. A. Clubb.
Halichondria and Sycon, A. Dendy.

In addition to these, other Memoirs will be arranged for, on suitable types, such as *Pagurus*, *Pontobdella*, a Cestode and a Pycnogonid.

In conclusion, I would again point out that, in view of the loss of so many of their old fellow-workers and supporters in the last few years, the Committee are most anxious to get some additional younger men as recruits to fill the places thus left vacant—either as actual workers in the field or as subscribers to the funds. There are now a goodly number of University students—in fact, during the Easter vacation the laboratory of the Biological Station has, for the last few years, been practically full—and there are plenty of young professional researchers; but we have very few left of the earnest amateur naturalists who were our main support in the early days twenty years ago.

Such men have been one of the glories of British Natural Science in the past, and their enthusiastic and disinterested work in the last generation laid the foundations of much that we are now building.

Professional biologists would gladly welcome more of the race as fellow-workers. Local biological stations, with their unique combination of field-work and laboratory facilities and apparatus, should give the amateur or non-professional, but serious naturalist opportunities such as his predecessors never had of applying keen powers of observation and detailed knowledge of living nature to the more advanced problems of modern science. There is no more fascinating and practically useful study for such men—or women— than marine biology; and surely no more pleasant country place in which to engage in this work than Port Erin can be found within easy reach of Liverpool.



Back view of the Port Erin Biological Station as it has been in the past, showing at the right-hand end where the new research wing has now been added. The ground plan of the building as it was is seen on p. 49, and as it now is on p. 15.

We append to this Report:—

(A) The usual Statement as to the constitution of the L.M.B.C., and the Laboratory Regulations;

(B) The Hon. Treasurer's Report, List of Subscribers, and Balance Sheet.

Appendix A.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE (1910).

His Excellency the Right Hon. Lord Raglan, Lieut.-Governor of the Isle of Man.

Rt. Hon. Sir John Brunner, Bart., M.P.

Prof. R. J. Harvey Gibson, M.A., F.L.S., Liverpool.

Mr. W. J. Halls, Liverpool.

Prof. W. A. Herdman, D.Sc., F.R.S., F.L.S., Liverpool, Chairman of the L.M.B.C., and Hon. Director of the Biological Station.

Mr. P. M. C. Kermode, Ramsey, Isle of Man.

Prof. Benjamin Moore, Liverpool.

Sir Charles Petrie, Liverpool.

Mr. E. Thompson, Liverpool, Hon. Treasurer.

Mr. A. O. Walker, F.L.S., J.P., formerly of Chester.

Mr. Arnold T. Watson, F.L.S., Sheffield.

Curator of the Station—Mr. H. C. Chadwick, A.L.S.

Assistant—Mr. T. N. Cregeen.

CONSTITUTION OF THE L.M.B.C.

(Established March, 1885.)

I.—The OBJECT of the L.M.B.C. is to investigate the Marine Fauna and Flora (and any related subjects such as submarine geology and the physical condition of the water) of Liverpool Bay and the neighbouring parts of the Irish Sea and, if practicable, to establish and maintain a Biological Station on some convenient part of the coast.

II.—The COMMITTEE shall consist of not more than 12 and not less than 10 members, of whom 3 shall form a quorum; and a meeting shall be called at least once a year for the purpose of arranging the Annual Report, passing the Treasurer's accounts, and transacting any other necessary business.

III.—During the year the AFFAIRS of the Committee shall be conducted by an HON. DIRECTOR, who shall be Chairman of the Committee, and an HON. TREASURER, both of whom shall be appointed at the Annual Meeting, and shall be eligible for re-election.

IV.—Any VACANCIES on the Committee, caused by death or resignation, shall be filled by the election at the Annual Meeting, of those who, by their work on the Marine Biology of the district, or by their sympathy with science, seem best fitted to help in advancing the work of the Committee.

V.—The EXPENSES of the investigations, of the publication of results, and of the maintenance of the Biological Station shall be defrayed by the Committee, who, for this purpose, shall ask for subscriptions or donations from the public, and for grants from scientific funds.

VI.—The BIOLOGICAL STATION shall be used primarily for the Exploring work of the Committee, and the SPECIMENS collected shall, so far as is necessary, be placed in the first instance at the disposal of the members of the Committee and other specialists who are reporting upon groups of organisms; work places in the Biological Station may, however, be rented by the week, month, or year to students and others, and duplicate specimens which, in the opinion of the Committee, can be spared may be sold to museums and laboratories.

LIVERPOOL MARINE BIOLOGICAL STATION
AT
PORT ERIN.

Laboratory Regulations.

I.—This Biological Station is under the control of the Liverpool Marine Biological Committee, the executive of which consists of the Hon. Director (Prof. Herdman, F.R.S.) and the Hon. Treasurer (Mr. E. Thompson).

II.—In the absence of the Director, and of all other members of the Committee, the Station is under the temporary control of the Resident Curator (Mr. H. C. Chadwick), who will keep the keys, and will decide, in the event of any difficulty, which places are to be occupied by workers, and how the tanks, boats, collecting apparatus, &c., are to be employed.

III.—The Resident Curator will be ready at all reasonable hours and within reasonable limits to give assistance to workers at the Station, and to do his best to supply them with material for their investigations.

IV.—Visitors will be admitted, on payment of a small specified charge, at fixed hours, to see the Aquarium and

Museum adjoining the Station. Occasional public lectures are given in the Institution by members of the Committee.

V.—Those who are entitled to work in the Station, when there is room, and after formal application to the Director, are:—(1) Annual Subscribers of one guinea or upwards to the funds (each guinea subscribed entitling to the use of a work place for three weeks), and (2) others who are not annual subscribers, but who pay the Treasurer 10s. per week for the accommodation and privileges. Institutions, such as Universities and Museums, may become subscribers in order that a work place may be at the disposal of their students or staff for a certain period annually; a subscription of two guineas will secure a work place for six weeks in the year, a subscription of five guineas for four months, and a subscription of £10 for the whole year.

VI.—Each worker is entitled to a work place opposite a window in the Laboratory, and may make use of the microscopes and other apparatus, and of the boats, dredges, tow-nets, &c., so far as is compatible with the claims of other workers, and with the routine work of the Station.

VII.—Each worker will be allowed to use one pint of methylated spirit per week free. Any further amount required must be paid for. All dishes, jars, bottles, tubes, and other glass may be used freely, but must not be taken away from the Laboratory. Workers desirous of making, preserving, or taking away collections of marine animals and plants, can make special arrangements with the Director or Treasurer in regard to bottles and preservatives. Although workers in the Station are free to make their own collections at Port Erin, it must be clearly understood that (as in other Biological Stations) no specimens must be taken for such purposes from the

Laboratory stock, nor from the Aquarium tanks, nor from the steam-boat dredging expeditions, as these specimens are the property of the Committee. The specimens in the Laboratory stock are preserved for sale, the animals in the tanks are for the instruction of visitors to the Aquarium, and as all the expenses of steam-boat dredging expeditions are defrayed by the Committee, the specimens obtained on these occasions must be retained by the Committee (*a*) for the use of the specialists working at the Fauna of Liverpool Bay, (*b*) to replenish the tanks, and (*c*) to add to the stock of duplicate animals for sale from the Laboratory.

VIII.—Each worker at the Station is expected to lay a paper on some of his results—or at least a short report upon his work—before the Biological Society of Liverpool during the current or the following session.

IX.—All subscriptions, payments, and other communications relating to finance, should be sent to the Hon. Treasurer. Applications for permission to work at the Station, or for specimens, or any communications in regard to the scientific work should be made to Professor Herdman, F.R.S., University, Liverpool.

APPENDIX B.

HON. TREASURER'S STATEMENT.

The Annual Subscription List and Balance Sheet are here shown, and it is very gratifying to note that two more Colleges have become subscribers to work-tables for the use of students at Port Erin, and the Treasurer hopes that, now the Biological Station has been enlarged, other Universities and Colleges will likewise join.

The Balance Sheet shows a small balance in hand, but there is still considerable need for more financial support. As the work done at Port Erin increases so rapidly the expenses naturally become heavier, and the Treasurer earnestly hopes that more subscribers will be forthcoming in order that the useful work may be carried on without being handicapped through lack of funds.

The important financial item of the year has been the new addition to the buildings at Port Erin, the expenses in connection with which are being kept as a separate account. The circumstances are as follows :—

In May the Treasurer received the following letter from Professor Herdman, which was printed and sent with a covering note from the Treasurer to a few members of the Committee and others who have in the past taken an interest in the work carried on at Port Erin, or might be expected to do so in the future :—

"UNIVERSITY OF LIVERPOOL,
May 5*th*, 1910.

MY DEAR TREASURER,

This is a letter for you to show to anyone you like, giving the facts in regard to a very desirable and much needed possible extension of the Port Erin Biological Station.

The present building, with its Fish Hatchery, Aquarium and Scientific Laboratory, was erected at a cost of £2,000 by the Manx Government, in 1901.

The Laboratory wing contains on the upper floor a large room designed for about 12 senior students, and, on the ground floor, six small work-rooms for researchers, a small library, a store-room, a dark room for photography and a workshop. Consequently there is accommodation for about 20 students and researchers working simultaneously.

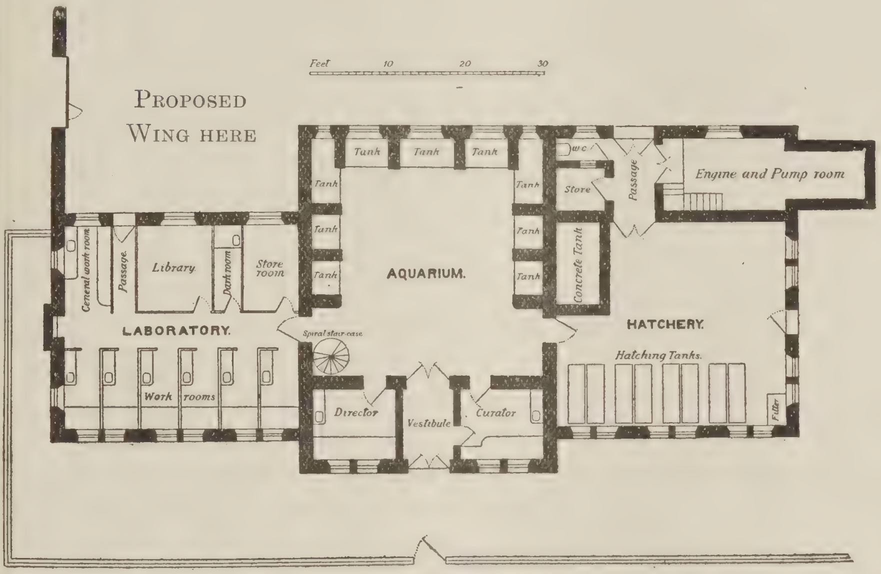
For the last three or four sessions these rooms have all been fully, or more than fully, occupied during the spring vacation. In 1908 the numbers were 20 students and six research workers; in 1909 there were 21 students and nine researchers; and this present year the numbers during four weeks in March and April reached 40 in all (30 students and 10 professional Zoologists doing research). These 40 workers represented the Zoology departments of at least six universities.

This overcrowding is satisfactory in one sense, as it is gratifying evidence of the success of the institution, but it is unsatisfactory in other respects since it causes discomfort, less perfect work, and some complaints. Every student and every scientific man who has visited the institution at the busy season lately has been convinced that the laboratory and library accommodation ought, if possible, to be increased without delay.

The only possible extension, on the Government land allocated and enclosed in 1901, would be a wing running back from the East end of the present Laboratory towards the cliff (left-hand upper corner on the accompanying plan). A building in such a position, 42 feet by 17 feet and two storeys high could be erected for about £300, including heating, lighting and simple laboratory fittings. In the lower floor it would provide an extension of the library and store-room, an experimental tank room and two additional laboratories, while on the upper floor would be a series of eight little work-rooms for researchers, looking out four to the East and four to the West.

In the hope that when these facts were made known, some friend of the Liverpool Marine Biology Committee, wishing to encourage both the original investigations into marine life and also the teaching of senior students, might be willing to provide the necessary funds for such an addition, I obtained plans from Mr. J. McArd (the builder at Port Erin who erected the present Biological Station) and have laid them before the Governor (Lord Raglan) and the Fisheries Board, and secured the necessary consent of both these authorities to the erection of such an extension on this site.

Consequently, all that remains is to find the money and get this very necessary addition to the laboratory completed before the next busy season comes round, and here, Mr. Treasurer, I naturally turn to you.



I think you will be able to show from our Annual Reports:—

1.—That the Biological Station is much appreciated by men of science, and has for some years been utilised to the fullest extent, both by senior students and for research;

2.—That much good original work is being turned out from the Laboratory every year by our young researchers;

3.—That the whole concern is worked in a most economical manner. A great deal of the service that is paid for in other similar institutions at home and abroad is here given gratuitously, and every penny spent is on essential running expenses.

On the Continent of Europe such institutions as ours are usually erected and maintained in the most liberal manner by the State or from other public funds. In America, on the other hand, as in our country these scientific and educational buildings are usually left to private enterprise, and in visiting them one finds laboratory after laboratory, with occasional libraries and students' dormitories, named after the donors who have added them. We have had a few generous friends in the past who rendered possible the foundation and the early success of the Liverpool Marine Biology Committee. I hope you will find we have still friends in Liverpool who are willing to help us to proceed further in our investigation of the sea and its inhabitants, and in teaching the results obtained.

I am, my dear Treasurer,

Yours very truly,

W. A. Herdman.

Edwin Thompson, Esq.,
Hon. Treasurer of the L.M.B.C."

The response has been most gratifying and the Committee specially thank Mrs. and Miss Holt for the generous donation of nearly half the amount required. £300 was originally asked for, but when a more detailed estimate was obtained it became evident that, including such necessary extras as heating and lighting, £350 would be required to cover the total cost. Subscriptions amounting to £295 15s. 0d. (as shown in the following list) have been received, and if £8 8s. 0d. received as one third share of the fees for the Oceanography Course be added to this fund there is a deficit left of about £46, towards which the Committee hope some further subscriptions will be added in order that the new wing may be thoroughly equipped with the necessary fixtures before next Easter

List of Subscribers to the new Research Building:—

	£	s.	d.
Mrs. and Miss Holt	150	0	0
Professor Herdman	25	0	0
A. O. Walker, Esq.	25	0	0
A. T. Watson, Esq.	25	0	0
Dr. Alfred Holt	20	0	0
Dr. Tempest Anderson	10	10	0
Alfred Holt, Esq.	10	0	0
William Johnston, Esq.	10	0	0
United Alkali Co., Ltd.	10	0	0
Miss M. Rathbone	5	5	0
A. T. Smith, Esq.	5	0	0
	£295	15	0

No call has been made upon the Memoir Fund for publications during the year, but the Memoir on the Whelk is nearly ready, and the Treasurer will no doubt shortly be called upon to defray the expenses of producing the plates, consequently the sum of £70 has been transferred to that Fund from the general account.

Edwin Thompson,
Hon. Treasurer.

1, Croxteth Grove,
Liverpool.
December, 1910.

SUBSCRIBERS.

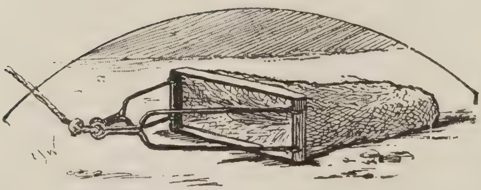
	£	s.	d.
Beaumont, W. I., Citadel Hill, Plymouth ...	1	1	0
Briscoe, F. W., Colby, Isle of Man	0	10	6
Brown, The late Prof. J. Campbell, University, Liverpool	1	1	0
Browne, Edward T., B.A., Anglefield, Berkhamsted, Herts.	1	1	0
Boyce, Sir Rubert, F.R.S., University, Liverpool	1	1	0
Brunner, Mond & Co., Northwich...	1	1	0
Brunner, Rt. Hon. Sir John, Bart., Silverlands, Chertsey	5	0	0
Brunner, J. F. L., M.P , 23, Weatherley Gardens, London, S.W.	2	2	0
Bullen, Rev. R. Ashington, Heathside-road, Woking	1	1	0
Caton, Dr., 78, Rodney-street, Liverpool	1	1	0
Clubb, Dr. J. A., Public Museums, Liverpool ...	0	10	6
Cole, Prof., University College, Reading	1	1	0
Crellin, John C., J.P., Andreas, I. of Man... ...	0	10	0
Crosfield, Harold G., Oxton, Birkenhead	1	1	0
Dale, Vice-Chancellor, University, Liverpool ...	1	1	0
Dixon-Nuttall, F. R., J.P., F.R.M.S., Prescot ...	2	2	0
Eliot, Sir Charles, University, Sheffield	1	1	0
Ellis, R. Williams, Chwilog, N. Wales	1	1	0
Halls, W. J., 35, Lord-street, Liverpool	1	1	0
Headley, F. W., Haileybury College, Hertford ...	1	1	0
Herdman, Prof., F.R.S., University, Liverpool ...	2	2	0
Hewitt, David B., J.P., Northwich	1	1	0
Hickson, Prof., F.R.S., University, Manchester ...	1	1	0
Holland, Walter, Carnatic Hall, Mossley Hill ...	1	1	0
Holt, Alfred, Crofton, Aigburth, Liverpool ..	2	2	0
Holt, Dr. Alfred, Crofton, Aigburth, Liverpool ...	1	0	0
Holt, Mrs., Sudley, Mossley Hill, Liverpool ...	2	2	0
Holt, P. H., Croxteth-gate, Sefton-park, Liverpool	1	1	0
Forward	£36	19	0

	£	s.	d.
Forward... ...	36	19	0
Isle of Man Natural History Society	2	2	0
Jarmay, Gustav, Hartford, Cheshire	1	1	0
Lever, W. H., Thornton Hough, Cheshire ...	1	1	0
Lewis, Dr. W. B., W. Riding Asylum, Wakefield...	1	1	0
Livingston, Charles, 16, Brunswick-st., Liverpool	1	1	0
Manchester Microscopical Society...	1	1	0
Meade-King, R. R., Tower Buildings, Liverpool...	0	10	0
Mond, R., Sevenoaks, Kent...	5	0	0
Monks, F. W., Warrington...	2	2	0
Muspratt, Dr. E. K., Seaforth Hall, Liverpool ...	5	0	0
Narramore, W., Cambridge Avenue, Great Crosby	1	1	0
O'Connell, Dr. J. H., Dunloe, Heathfield-road, Liverpool	1	1	0
Petrie, Sir Charles, Devonshire-road, Liverpool ...	1	1	0
Rae, Edward, Courthill, Birkenhead	1	1	0
Rathbone, Mrs. Theo., Backwood, Neston... ...	1	1	0
Rathbone, Miss May, Northumberland-street, London	1	1	0
Rathbone, Mrs., Green Bank, Allerton, Liverpool	2	0	0
Roberts, Mrs. Isaac, Thomery, S. et M., France ...	1	1	0
Robinson, Miss M. E., Holmfield, Aigburth, L'pool	1	0	0
Simpson, the late J. Hope, Ivy lodge, Aigburth, Liverpool	0	10	6
Smith, A. T., 43, Castle-street, Liverpool... ...	1	1	0
Tate, Sir W. H., Woolton, Liverpool	2	2	0
Thompson & Capper, 4, Lord-street, Liverpool ...	1	1	0
Thomson, Dr. J. Stuart	1	1	0
Thornely, Miss, Nunclose, Grassendale	0	10	0
Thornely, Miss L. R., Nunclose, Grassendale ...	2	2	0
Toll, J. M., 49, Newsham-drive, Liverpool ...	1	1	0
Walker, Alfred O., Ulcombe Place, Maidstone ...	3	3	0
Watson, A. T., Tapton-crescent Road, Sheffield ...	1	1	0
Forward	£80	17	6

	£	s.	d.
Forward	80	17	6
Whitley, E., Clovelly, Sefton-park, Liverpool ...	2	2	0
Weiss, Prof. F. E., University, Manchester ...	1	1	0
Wiglesworth, Dr., Rainhill...	1	1	0
Wragg, Sir W., D.C.L., Port St. Mary, Isle of Man	1	1	0
Yates, Harry, 75, Shudehill, Manchester	1	1	0
	£87	3	6
Deduct Subscriptions still unpaid, *less* old Subscriptions received	1	11	6
	£85	12	0

Subscriptions for the Hire of "Work-Tables."

Victoria University, Manchester	£10	0	0
University, Liverpool	10	0	0
University, Birmingham	10	0	0
Bedford College for Women, London	2	2	0
University College, Reading	2	2	0
	£34	4	0



The Naturalist's Dredge.

THE LIVERPOOL MARINE BIOLOGY COMMITTEE.

Dr. IN ACCOUNT WITH EDWIN THOMPSON, HON. TREASURER. **Cr.**

1910.	£	s.	d.
To Printing and Stationery	4	3	0
,, Printing Reports	21	0	2
,, Boat Hire	5	0	0
,, Books and Apparatus at Port Erin Biological Station	10	12	0
,, Postage, Carriage, &c.	8	12	4
,, Natural History Specimens	0	6	3
,, Salary—Share of Curator's	75	0	0
,, ,, ,, Assistant's	27	6	0
,, Sundries	12	1	5
,, Amount transferred to Memoir Fund	70	0	0
,, ,, ,, Extension Fund	50	0	0
,, Balance in hand December, 1910	12	4	3
	£296	5	5

EDWIN THOMPSON,
HON. TREASURER.

LIVERPOOL, *December 17th, 1910.*

1910.	£	s.	d.
By Balance in hand December, 1909	1	12	8
,, Subscriptions and Donations received	85	12	0
,, Amount received from Universities for hire of "Work Tables"	34	4	0
,, Sale of Specimens, Bottles, &c.	3	15	1
,, Interest on British Association (1896) Fund	37	13	4
,, Bank Interest	2	15	10
,, Laboratory and Class Fees	6	11	6
,, Sale of Guides	8	1	0
,, Admissions to Aquarium, Share of	28	16	5
,, Sale of Memoirs	87	3	7
	£296	5	5

	£	s.	d.
Endowed Invested Fund:—			
British Workman's Public House Co. 99 Shares £1 each fully paid.			
Memoir Fund—Balance in Bank	£149	6	0
Extension Fund:—			
Donations received to date	295	15	0
Oceanographical Course	8	8	0
Transferred from General Account	50	0	0

Audited and found correct,
COOK & LEATHER,
Chartered Accountants.

POLYCHAETA OF THE PORT ERIN DISTRICT.

By W. Riddell, M.A., Fisheries Assistant in the Zoological Department, University of Liverpool.

The Polychaeta of the South end of the Isle of Man have never been systematically investigated. Only about thirty species from this locality are included in the lists published by Harvey Gibson and by Hornell in the "Fauna of Liverpool Bay" (Vol. I and Vol. III), and a few additional records have been noted from time to time in the Annual Reports of the Port Erin Biological Station. In the present list I have included all previous records which could be traced. For about thirty of the species collected I can find no previous records, and sixteen of these seem to be new also to the L.M.B.C. district in general. Three or four of these species had been previously observed by the Curator of the Biological Station, Mr. H. C. Chadwick, but never recorded, and he has kindly allowed me to examine his specimens. Sixteen species are the result of three dredging expeditions carried out by Prof. Herdman in the S.Y. "Ladybird" last summer. I have no doubt that further work would add considerably to this list, as regards both littoral and deep water forms. It may be of some interest to note here separately, for comparison, the results of the three dredging expeditions referred to.

Off N. side of Calf Island, August 13th, 1910.—†*Syllis cornuta*, †*S. krohnii*, †*Trypanosyllis zebra*, *Amblyosyllis lineata*, **Castalia punctata*, *Lepidonotus squamatus*, *Halosydna gelatinosa*, *Nereis pelagica*, *Chaetopterus variopedatus*, †*Dodecaceria concharum*, *Terebella nebulosa*, †*Melinna cristata*, *Serpula vermi-*

cularis, Pomatoceros triqueter, Filograna implexa, Spirorbis borealis, **S. lucidus.*

Off the Carron, N. of Bradda, August 22nd, 1910.—**Syllis armillaris,* **Castalia punctata,* †*Magalia perarmata, Lepidonotus squamatus, Lagisca floccosa, Polynoe scolopendrina, Nereis dumerilii, N. pelagica,* †*Polydora flava,* †*Dodecaceria concharum, Terebella nebulosa,* **Dasychone herdmani, Serpula vermicularis,* **S. reversa, Pomatoceros triqueter, Spirorbis borealis.*

Houlth Bank, 2 miles N. of Fleshwick, September 14th, 1910.—**Syllis armillaris,* †*S. cornuta, Hermione hystrix, Lepidonotus squamatus, Lagisca floccosa, Harmothoe imbricata, Halosydna gelatinosa, Scalisetosus assimilis,* †*Eumida sanguinea, Phyllodoce laminosa, Nereis pelagica, Lumbriconereis fragilis,* †*Glycera lapidum,* **Ephesia gracilis,* †*Aricia cuvieri, Terebella nebulosa,* **Pectinaria auricoma,* **Siphonostoma affinis, Serpula vermicularis, Pomatoceros triqueter, Filograna implexa, Spirorbis borealis.*

Forms marked * are new to Port Erin, those marked † are new to the L.M.B.C. records in general.

In brief, I have evidence of the existence of about 85 species, of which the following is a detailed list:—

LIST OF PORT ERIN POLYCHAETA.

SYLLIDAE.

**Syllis armillaris,* Müll.—A few specimens have been taken on the shore; one or two were dredged on the Houlth Bank, between Port Erin and Niarbyl.

†*Syllis cornuta,* Rathke.—One specimen only, dredged off the Calf Island.

†*Syllis krohnii,* Ehlers.—One specimen, off the Calf Island.

Pionosyllis lamelligera, de St. Jos.—Recorded by Gravely (21st Annual Report), and I have taken one specimen in the dredge outside Port Erin breakwater.

Odontosyllis ctenostoma, Cpde. — Recorded by Gravely (*loc. cit.*).

†*Trypanosyllis zebra*, Grube.—A few off the Calf Island, and one at Port St. Mary.

Amblyosyllis lineata, Grube.—Recorded in the 10th Annual Report. I have taken it twice in the dredge off the Calf Island.

Autolytus prolifer, Müll.—Common in tow-nets, both in the bay and outside. All stages have been found.

Autolytus alexandri, Mgrn.—Recorded by Watson (10th Annual Report). I have seen one specimen, taken in the tow-net by Mr. Chadwick.

Autolytus incertus, Mgrn.—Recorded by Gravely (21st Annual Report).

Autolytus longisetosus, Oerst.—Recorded in 10th Annual Report, no locality given.

Myrianida pinnigera, Mont.—Gravely, 21st Annual Report; under stone on shore.

Hesionidae.

**Castalia punctata*, Müll. — Not uncommon in dredgings, off Calf Island and off the Carron.

†*Magalia perarmata*, Mar. and Bobr.—One specimen only, dredged off the Carron.

Aphroditidae.

Aphrodite aculeata, L.—Recorded originally by Forbes. Has also been taken off Peel, on the North Bank.

Hermione hystrix, Sav.—Recorded by both Gibson and Hornell. I have taken it on the Houlth Bank.

Lepidonotus squamatus, L.—Common on the shore and in all dredgings.

Lagisca floccosa, Sav.—Common on the shore. Dredged off the Carron.

Lagisca extenuata, Grube.—Recorded by Hornell, one specimen only.

Harmothoe imbricata, L.—Fairly common on the shore under stones, in all varieties of coloration. Dredged on the Houlth Bank.

Harmothoë haliaeti, McI.—Recorded by Hornell.

Scalisetosus assimilis, McI.—Recorded by Hornell. I have taken it in the dredge on the Houlth Bank.

Halosydna gelatinosa, M. Sars.—A few specimens have been taken in the dredge in most localities.

Polynoe scolopendrina, Sav.—Two specimens, in tubes of *Terebella*, dredged off the Carron.

Panthalis oerstedi, Kimb.—Dredged 14 m. W. of Dalby, 60 fath., bottom mud. (See 6th Annual Report.)

Sthenelais boa, Johnst.—Used to be fairly common in the sand at the mouth of Port Erin harbour, but seems to be disappearing.

Sthenelais zetlandica, McI.—This was recorded by Gibson from a mutilated fragment dredged off Port Erin. Hornell seems to have doubted the identification, but I have found, in the Zoological Department of the University, a preparation showing a parapodium of the original specimen, which enables me to confirm Gibson's identification. This is the only record.

Amphinomidae.

Spinther (?) *oniscoides*, Johnst. — This form is recorded in a manuscript list of species dredged by Professor Herdman on the Ballaugh Bank; I have been unable to find the specimen. The identification was made by Mr. H. J. B. Wollaston, and I know that he was familiar with the Belfast Lough species, which I have shown (Irish Nat. XVIII, 5, 1909) to be Johnston's species. Consequently, though the species is queried, I have little real doubt on the point.

Phyllodocidae.

Eulalia viridis, Müll.—Has been taken on the shore and on the breakwater, but is not common. I have taken one specimen, on the shore. Professor Herdman informs me that it is much commoner on the limestone rocks at Port St. Mary.

Phyllodoce laminosa, Sav.—Recorded by Hornell. I have taken one or two on the shore, and one in the dredge on the Houlth Bank.

**Phyllodoce maculata*, Müll.—I have taken one specimen on the shore.

†*Eumida sanguinea*, Oerst.—One specimen, dredged on the Houlth Bank.

Tomopteridae.

Tomopteris catharina (Gosse), Rosa.—This is the species which has been usually identified with *T. onisciformis*, Esch., but which Rosa has recently shown to be really the *T. catharina* of Gosse. (*Raccolte Planctoniche*, etc., V, Annelidi, Firenze, 1908.)

Nereidae.

Nereis pelagica, L.—Common throughout the district, both littoral and in all dredgings.

Nereis dumerilii, A. and E.—Dredged off the Carron. Recorded by Hornell.

Nereis fucata, Sav.—Common in shells inhabited by *Eupagurus bernhardus*.

Nephthydidae.

Nephthys caeca, Fabr.—In the sand, not common, though fairly large.

Nephthys hombergi, A. and E.—In the sand, fairly common.

Eunicidae.

**Eunice harassi*, A. and E.—I have one specimen of this species from Port Erin, but the label recording the exact locality has been lost.

Onuphis conchilega, M. Sars.—I have identified this among specimens dredged on Ballaugh Bank. It has been taken fairly often on dredging expeditions.

Hyalinoecia tubicola, Müll.—This is recorded in the 7th Annual Report from dredgings off the Calf Island.

Lumbriconereis fragilis, Müll. — Recorded by Gibson. I have taken one or two specimens on the Houlth Bank.

†*Ophryotrocha puerilis*, Cpde. and Mecz. — This occurs regularly in one of the aquarium tanks at the Biological Station. One specimen (with ova) was found this summer in débris from the harbour buoy.

Glyceridae.

†*Glycera lapidum*, Qfges.—A few were dredged on the Houlth Bank.

Glycera alba, Rathke.—Recorded from deep water, 11th Annual Report, by Arnold T. Watson.

†*Glycera goesi*, Mgrn.—Thrown up on the shore during a storm, February, 1903.

**Goniada maculata*, Oerst.—Found at the same time as the last species.

Sphaerodoridae.

**Ephesia gracilis*, Rathke. — A few specimens dredged on the Houlth Bank.

Ariciidae.

†*Aricia cuvieri*, A. and E.—One incomplete specimen (part of the posterior end missing) was dredged on the Houlth Bank.

Scoloplos armiger, Müll.—Not uncommon in the sand near the harbour. Recorded by Hornell from Peel.

Spionidae.

†*Scolelepis fuliginosa*, Cpde.—Fairly common in the sand between tide-marks at Port Erin.

(?) *Scolelepis vulgaris*, Johnst.—This species is recorded by Hornell, but I have never found it. While it is possible that the two co-exist, I am inclined to suspect that this should be *S. fuliginosa*.

Nerine cirratulus, D. Chiaje.—In the sand, not so common as *Scolelepis fuliginosa*.

†*Polydora flava*, Cpde.—Dredged off the Carron, in old shells.

Polydora ciliata, Johnst.—Recorded by Hornell. I have not found it.

Chaetopteridae.

Chaetopterus variopedatus, Renier.—Tubes of this form are common in dredgings, but I have only found two specimens of the living animal.

Magelonidae.

Magelona papillicornis, Müll.—Common in the sand between tide-marks.

Ammocharidae.

Owenia filiformis, D. Ch.—Recorded in 9th Annual Report.

Cirratulidae.

Cirratulus cirratus, Müll.—Recorded from Port Erin Bay by Hornell. I have found it also at Port St. Mary.

†*Dodecaceria concharum*, Oerst.—One specimen, in a shell of *Pecten maximus*, dredged off the Calf Island, and one off the Carron.

Terebellidae.

Amphitrite johnstoni, Mgrn.—Not uncommon on the shore.

Terebella conchilega, Pall.—Numerous in the sand above low water mark.

Terebella nebulosa, Mont.—Common in dredged material from all localities.

Ampharetidae.

†*Melinna cristata*, Sars.—Dredged in fair numbers off Calf Island.

Amphictenidae.

Pectinaria belgica, Pall.—Recorded by Gibson. I can find no other records.

**Pectinaria auricoma*, Müll.—One empty tube of this species was dredged on the Houlth Bank. Larval forms of *Pectinaria* are not uncommon.

Capitellidae.

Capitella capitata, v. Ben.—Recorded by Hornell. I have found it on the shore under stones.

Opheliidae.

Ammotrypane aulogaster, Rathke.—Occasional in the dredge. The only specimen I have seen came from near Bradda Head.

Maldanidae.

Praxilla gracilis, Sars.—Recorded in the 11th Annual Report as dredged along with *Panthalis*.

Arenicolidae.

Arenicola marina, L.—Common everywhere in the sand.

Arenicola ecaudata, Johnst.—Not so common as the last.

Arenicola grubei, Cpde.—This and the last species occur both at Port Erin and at Bay ny Carrickey. See the report by Gamble and Ashworth in 11th Annual Report.

Chlorhaemidae.

**Siphonostoma* (*Flabelligera*) *affinis*, Sars.—One specimen, dredged on the Houlth Bank.

Sabellidae.

Sabella pavonia, Sav.—Recorded by Hornell. Occurs occasionally in the dredge, but is not common.

**Dasychone bombyx*, Dalyell, var. *herdmani*, Hornell.—Dredged on the Houlth Bank. This is the form described by Hornell as *D. herdmani*. Except the spathulate form of the dorsal appendages, with their frilled margins, I can find no points of distinction from the ordinary *D. bombyx*. I therefore prefer to regard this as a variety rather than as a distinct species.

†*Potamilla reniformis*, Müll.—So far this has only been found in one of the aquarium tanks, where it has recently appeared.

Eriographidae.

†*Myxicola infundibulum*, Mont.—This species also has only occurred in the tanks, and then only a few specimens.

†*Amphiglena mediterranea*, Leyd.—Found by Mr. Chadwick, but not recorded. [It may be of interest to note here that I have found a specimen of *Amphiglena mediterranea* in the Zoology Department, Liverpool University, collected by the late Mr. I. C. Thompson at Penmaenmawr in 1885, but never identified.]

Serpulidae.

Serpula vermicularis, Ellis.—Common everywhere in the dredge.

**Serpula reversa*, Mont.—Dredged off the Carron. According to Hornell this is "the most abundant deep water Serpulid" in the Liverpool district, but I have only found it once at Port Erin.

Pomatoceros triqueter, L.—Common everywhere in the dredge.

Filograna implexa, Berk.—Common in dredged material.

Spirorbis borealis, Daudin.—Common, both littoral and in deep water.

**Spirorbis lucidus*, Mont.—Dredged off the Calf Island, on *Sertularia abietina*.

†*Salmacina dysteri*, Huxley.—For this also I am indebted to Mr. Chadwick; his specimen is the only one I have seen.

Hermellidae.

Sabellaria alveolata, L.—Recorded in the MS. list of species dredged by Professor Herdman on Ballaugh Bank.

In addition to the above, the following two larval forms, of which adults have not yet been found, have been recorded by Gravely. (L.M.B.C. Memoirs, No. XIX.)

Mystides sp.—A form belonging to the sub-genus *Mesomystides* of Cziernavsky, thus distinguished from *Mystides lizziae*.

Poecilochaetus sp. (Spionid A).—Recorded by Gravely as being very abundant in every tow-netting during July.

Addenda.

Nereis virens, Sars.—Dr. W. J. Dakin informs me that one specimen was taken this year (1911) on the shore at Port Erin.

Glycera siphonostoma, Delle Chiaje.—Thrown up on shore in a storm, 1903, length about eighteen inches.

NOTES ON *JASSA FALCATA* (MONT.).

BY ALFRED O. WALKER, F.L.S.

In the autumn of 1910 I received from Professor W. A. Herdman a tube containing scrapings from the buoy moored at the entrance of Port Erin Bay (Isle of Man). The Crustacea contained in this comprised the following species:—

ISOPODA.

Idothea pelagica, Leach; G. O. Sars. One male, length 10 mm. Not previously recorded from the Liverpool District. Colour, in spirit, white with reddish-brown blotches.

AMPHIPODA.

Stenothoe monoculoides (Montagu). Several; length of largest, female with ova, 3·3 mm.

Gammarus locusta, Leach. One; length 6 mm.

Jassa falcata (Montagu). A large number, mostly young.

Caprella linearis sp., Bate. One female with ova, one young.

JASSA FALCATA (Montagu, 1808).

Jassa pulchella, Leach, 1814. Stebbing, Ann. and Mag. N.H. (7), Vol. III, 1899, pp. 239-40. Gamm. d. Tierreich, p. 654, 1906.

Bruzeliella falcata (Mont.). Norman, Ann. and Mag. N.H. (7), Vol. XVI, 1905, p. 83.

A few words are necessary on the above name as to which I find myself in disagreement with our two greatest amphipodists—Canon A. M. Norman, F.R.S., in the genus, and Rev. T. R. R. Stebbing, F.R.S., in the species. Up to 1899 this form was universally known as *Podocerus falcatus* (Mont.). But in that year Mr. Stebbing published a paper (Ann. and Mag. Nat.

Hist., Ser. 7 (1899), Vol III, p. 240) in which he showed that the genus *Podocerus*, Leach, belonged to a different family, and that Leach's genus *Jassa* must be adopted in its place for the above species. He also proposed *Parajassa* for Leach's *Jassa pelagica*, previously known as *Podocerus capillatus*, Rathke, *Janassa variegata*, Boeck, &c., &c. In Ann. and Mag. N.H., Ser. 7, Vol. XVI (1905), p. 83 (Note), Canon Norman calls attention to the fact that Bruzelius in 1859 had restricted the use of *Jassa* to the species with a *rudimentary* secondary appendage in the upper antennæ, so that it could not be used for *Pulchella*, Leach (= *falcata*, Mont.), which has a quite distinct appendage. He therefore proposed a new genus *Bruzeliella* for this last, *Jassa*, instead of *Parajassa*, being used for *pelagica*, Leach, and, in deference to Canon Norman's high authority, I adopted his genus in my Indian Ocean amphipoda. Mr. Stebbing on the appearance of my paper wrote to me as follows:—"Leach in 1814 "instituted *Jassa* for *J. pulchella*, *J. pelagica*, and "probably *J. falcata* (Montagu). In 1816 he republished "*Jassa*, assigning to it the single species *J. pulchella*. "How could Bruzelius in 1859 have a right to restrict "*Jassa* to *pelagica*, when Leach himself restricted it to "*pulchella?*" Mr. Stebbing's argument convinced me, and I have gladly adopted the older and shorter name.

As to the question of *pulchella*, Leach, or *falcata* (Mont.), Mr. Stebbing's reasons for the former will be found in Ann. and Mag. N.H., Ser. 7, Vol. III (1899), p. 239, and the case for *falcata* at p. 395 of the same volume. To the remarks there I may add (1) that if Montagu's *Cancer* (*Gammarus*) *falcatus* is not our species, it is hard to say what it is;* and (2) that the

* Mrs. Sexton, who has examined Montagu's type specimen at the British Museum, informs me that "it is *unquestionably* this species."

name is sanctioned by long usage, as in the case of many other doubtful species. In this question I have the support of Canon Norman's high authority and can only express my regret that I cannot conform with that invaluable work, the Gammaridea of Das Tierreich.

The presence in the gathering of a colony of *Jassa falcata* in every stage of development, and taken from so small an area that the co-existence of a nearly allied species of the same genus is scarcely possible, invites a somewhat "intensive" study of this species. It is true that this was done by O. Nebeski* in 1880 on specimens obtained in Trieste harbour, but as his drawings of the 2nd gnathopods are only in outline, and as he does not appear to have met with the small forms of the ovigerous female and apparently sexually mature male, it seems worth while to carry on his investigations with the additional forms now available, and with the assistance of photographs of the 2nd gnathopods kindly executed under Professor Herdman's directions.

Taking the gnathopods in the order of development, we have (see Plate, figs. A to H):—

A. Young. Very numerous, constituting the bulk of the gathering, and ranging in size from freshly hatched individuals to 7 mm. The 2nd gnathopod in one 2 mm. long had the palm less concave than the figure, taken from one 7 mm. long. There is considerable variation in the relative size, but very little in the shape of the hand. It will be noticed that those figured are larger than those of the small ovigerous female (B). This is Nebeski's, Pl. IV, fig. 44, f. 1.

B. Small females with ova. Six specimens, 6 to 7 mm. The specimen whose gnathopods are figured had many well-formed ova. These gnathopods have not yet

*Arbeit. Inst. Wien, Vol. 3, p. 151, Pl. XIII (iv), fig. 44.

altered, but in one or two specimens the notch in the basal part of the hind margin, as in C, is apparent.

C. Large females with ova. Eleven specimens, 7·5 to 9 mm. Nebeski's figure, f. 2. There is a gradual transition from B to C in size, depth of notch, and acuteness of palmar angle.

It will probably be admitted, on comparing B with C, that the former has become *sexually* but not *structurally* mature. This is an important and disquieting fact for systematists, as many species have been separated on smaller differences than these. As far as size is concerned, I have noticed the same thing in the allied genus *Ischyrocerus;** also in *Calliopius leviusculus* (Kröyer).*

The Males.

The development of these, as indicated by the second gnathopods, is somewhat obscure. They are not easily distinguishable from females until they reach the penultimate stage. From this Nebeski states that they follow two distinct lines of development, viz., (*a*) *loc. cit.* fig. 44, Im^3, m^4, which he supposes to moult into the large adult form Im^5 (G in our plate), but of which I have not seen an example from any part of the Liverpool district, the nearest being that figured at E.

Our fig. D shows the 2nd gnathopod in course of the last moult, the distal dark-coloured part being the part to be shed, on the hind margin of which this rounded tooth is clearly to be seen. Our fig. H shows a smaller form of the penultimate stage, which would probably moult into the smaller limb (G). Mrs. Sexton, of the Marine Laboratory, Plymouth (who has given much time and attention to this species, and to whom I am indebted for valuable assistance in this matter), has

* Trans. L'pool. Biol. Soc., Vol. IX, 1895, pp. 313, 305.

seen IIm[2] moult into a large adult form, so that Nebeski is clearly mistaken. But the penultimate stage varies considerably; in a gathering from Port Erin breakwater (not more than 300 yards from the buoy), taken November, 1892, there is no projecting tooth in the middle of the palm: the adult males are smaller (5 mm. to 7 mm., 2nd gnathopods 1·3 to 2 mm. long), and have a shorter and more pointed "thumb"—in fact, they nearly resemble Nebeski's Im[3], m[4], which are probably adult males of the "breakwater" form. In both stages the males have the lower antennæ thickly clothed with plumose setae, of which the "buoy" specimens are destitute. There are 12 males in the penultimate and 14 in the adult stage in the "breakwater" collection: there are no intermediate forms.

Belonging to this or, more probably, to the final stage, is the form described by Professor G. O. Sars as *Podocerus odontonyx* (Amphipoda of Norway, p. 597, Pl. 213, f. 2), and previously by me as *P. herdmani* (Trans. Liverpool Biol. Soc., Vol VII (1893), p. 79, f. 13). I have more than once published my opinion that this is probably only a form of *J. falcata*,* and the occurrence of two specimens in this gathering confirms it. There are also two specimens in the above-mentioned "breakwater" collection, two in a gathering of *J. falcata* from the bottom of the "Clio" in the Menai Straits, and three in one from Puffin Island. It is always a small form, measuring in this instance 6 mm. The specimen originally described as *P. herdmani*, taken by Professor Herdman from a Compound Ascidian off the Island of Bute, measured only 3 mm., and was accompanied by two ovigerous females respectively 3 mm. and 4 mm. long. It may here be mentioned

* See Ann. and Mag. Nat. Hist., Series 8, Vol. VI, 1910, p. 33.

that a somewhat serious error has been made in the figure, the end of the "thumb" being shown emarginate, as in *Jassa pusilla* (Sars), whereas it is more or less pointed. The tooth on the dactylus is always present, though more prominent in some specimens than others; otherwise it nearly resembles Nebeski's Im^3, m^4, in which, as in this form, the "thumb" springs from the *middle* and not from the base of the hind margin. That it is not the form precedent to the final moult is shown by fig. D and by an adult male specimen in the "breakwater" gathering, which has the right gnathopod normal and the left as in the young male. It is probably a dimorphic male form.

The importance of these observations from the point of view of classification is obvious. As we have seen, ovigerous females in one gathering differ not only in size but also in the structure of the second gnathopods, so that the two forms, if taken in different localities, might easily be considered distinct species. So far as I know, this is the first record of dimorphism in females among the Amphipoda, though it is not uncommon in males.

Explanation of Plate.

Jassa falcata (Montagu), Second gnathopods of:—

A. Young, length 2 to 5 mm.

B. Small ovigerous female, 6 to 7 mm.

C. Large ovigerous female, 7·5 to 9 mm.

D. Male during final moult, 10 mm.

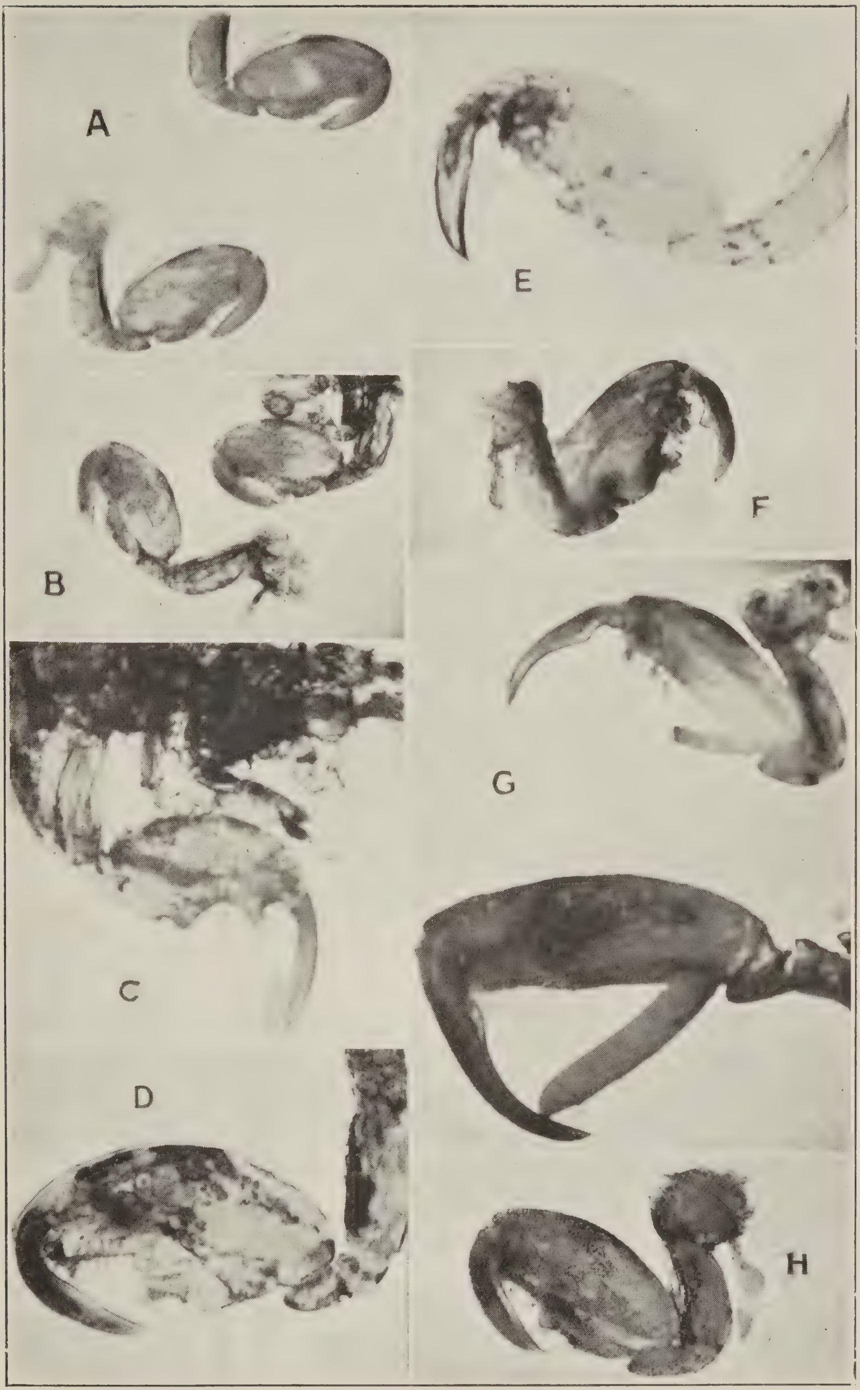
E. Male in the stage before D, 9 mm.

F. Form described as *P. herdmani*, A.O.W., 6 mm.

G. Adult males (the "thumb" in the small one is broken), 7 to 10 mm.

H. Another form of E—young male, 7 mm.

All the figures are magnified and photographed on the same scale.



JASSA FALCATA (MONTAGU).

REPORT on the INVESTIGATIONS carried on during 1910 in connection with the LANCASHIRE SEA-FISHERIES LABORATORY at the University of Liverpool, and the SEA-FISH HATCHERY at Piel, near Barrow.

Drawn up by Professor W. A. HERDMAN, F.R.S., Honorary Director of the Scientific Work; assisted by Mr. ANDREW SCOTT, A.L.S., Resident Fisheries Assistant at Piel; and Mr. JAMES JOHNSTONE, B.Sc., Fisheries Assistant at the Liverpool Laboratory.

(With plates and text figures.)

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INTRODUCTION.

It is impossible to pass over the recent death of Mr. John Fell, the first Chairman of the Sea-Fisheries Committee, without a few words of regret and appreciation on the part of the Scientific Staff. His services in organisation and administration are more fitly dealt with elsewhere, but a passing record of the part he played in connection with the scientific work of the

Committee may be made here. It was Mr. Fell who, at the time of the formation of the Committee, first induced me to take an interest in the application of marine biology to our local sea-fishing industries. He invited me to attend an enquiry which was held in Liverpool in 1889 for the purpose of taking evidence from fishermen and others interested in these fishery industries; and on many occasions subsequently, in these early years of our work, he consulted with me as to points in connection with the distribution and reproduction of fishes and the life processes of crustaceans and shell-fish.

It was, in fact, largely due to Mr. John Fell's support and encouragement that a scientific section of the Lancashire sea-fisheries work came to be established, and that, in 1892, a Sea-Fisheries Laboratory was instituted in connection with the Zoological Department of the University of Liverpool (then University College). He opened, with an introductory address, an Exhibition of Science as applied to the fisheries which we organised in this department of the University in 1897—an exhibition the essential part of which was shown during the next few years in London and in several of the more important towns of the county. Mr. Fell always recognised that sea-fisheries investigation forms a department of general marine biology, and that sound regulation and administration must be founded on the results of practical scientific investigation. Throughout the lengthy period that he remained as the valued and honoured Chairman of the Joint Committee, Mr. Fell's sympathy and encouragement were constantly of the greatest importance in connection with our scientific investigations.

Beginning in a humble way, under Mr. Fell's chairmanship, in 1892, with a small annual report of some fifty pages, and dealing at first with a very narrow range of fisheries investigation, the work of the scientific staff has so increased under our present Chairman, and with the help of the Scientific Sub-Committee, that it requires for adequate expression both a small Quarterly Report and a large Annual Report which has now increased to an illustrated volume of from 300 to 400 pages, taking the last three years as an example. The sections of this report are now written not by one, but by half a dozen different biologists, several of whom are volunteer workers. In fact, it is a remarkable feature of sea-fisheries research in this country that so much of it has been, and is being, done by scientific men who are not paid to do it, and that local sea-fisheries committees on some parts of the coast of England and Wales have been found willing to organise and subsidise the necessary series of investigations year after year without any help from the Imperial Treasury. There is reason to hope that this anomalous state of affairs will soon cease, and that Government subsidies, meeting the whole, or even only a portion, of the investigations will be given to all parts of the coast alike. Lancashire has been the pioneer county in the work of sea-fisheries investigation, and has practically undertaken unaided the work of the country so far as concerns the eastern half of the Irish Sea; and has carried out efficiently, by means of local funds supplemented by volunteer unpaid work, what is done in the English Channel to the South, in Scottish waters to the North, and off the Irish coasts opposite by steamers and investigators supported by Government funds. The claim of Lancashire to similar support is surely not only just but also strong.

In the present report Mr. Andrew Scott supplies the usual account of the hatching of edible flat fish (plaice and flounders) at Piel, which resulted in over thirteen millions of young fish being set free in the Lancashire waters. The time of spawning of these fish at Piel seems to be distinctly later than at Port Erin, where the first fertilised eggs of the plaice appeared, in the pond, in 1910 on March 14th, and in 1911 on February 13th, in each case some weeks earlier than at Piel. Both at Piel and at Port Erin, although the season in 1910 was late in beginning, the total numbers obtained were good. Mr. Scott gives the details for the Piel Hatchery, and it may interest the Committee to know that at Port Erin eleven and a half millions of plaice eggs were collected for incubation, and that over eight millions of young fish were distributed in the sea.

Mr. Scott also gives particulars of the practical classes in Marine Biology for fishermen, and in Nature Study for school teachers, held in the Piel Laboratory by Mr. Johnstone and himself during spring and early summer. A new edition of the illustrated syllabus of the course arranged for the fishermen's classes has been prepared during the past year, and is now in use.

We are again indebted to Dr. Bassett (of the Chemical Department of the University of Liverpool) for kindly undertaking the examination of the samples of sea-water obtained in our hydrographic cruises. Dr. Bassett's report on the results obtained in 1910 will be found below.

It is interesting to notice the successful prediction of the unusual weather of last summer made by Dr. Bassett in February (see our last Annual Report, p. 147). The prediction was based on the hydrographic observations showing the late appearance and reduced salinity of the Gulf Stream Drift early last year. This is an instance of the interest and value of these periodic observations as to the nature of the sea-water established in 1906 by the Committee. As Dr. Bassett points out, we have in two successive years a late and weak Gulf Stream Drift associated with a wet and gloomy summer. The hydrographic observations made during the present winter (October and December, 1910) showed that the Gulf Stream Drift is again becoming stronger; and, as Dr. Bassett states, observations taken this February fully bear out the conclusion that our sea-area is returning to a more normal state after the period of depression which it has experienced during the previous two years. It may be added that Mr. Scott and I have arrived at the same conclusion from an examination of the plankton samples, as will be seen in our article on the subject at the end of this report.

Mr. Johnstone's account of some additional parasites and diseased conditions of fish which have been sent to us at the Liverpool University Laboratory for examination during the year contains, amongst other interesting matters, a detailed description of a very remarkable "Melanotic Sarcoma," a pitch-black malignant tumour which we found attached to the head of a ray caught in our trammel net in Port Erin Bay last August. This is a rare occurrence, and a welcome addition to our scanty knowledge of the distribution of such cancerous growths in the lower animals.

In this report Mr. Johnstone gives us a general summary of all the results obtained up to date from the fish-marking experiments that have now been running for some years. No fresh plaice have been marked and liberated since 1908, but every now and again fish marked some two or more years ago are received. However, we think it probable that practically all the fish liberated which are likely to be recovered have now come to hand. The results of these experiments are very interesting and important. The whole of

Mr. Johnstone's remarks on the subject—both as to methods and on results—should be read, but I may call attention here to the suggested improvement in method for the future, viz., the adoption of a few large experiments in the year instead of a large number of small series of markings. As Mr. Johnstone points out, we now know well enough when and where plaice should be marked and liberated in the Irish Sea in order to give us the information that is required.

The results obtained in regard both to the migrations and to the growth of the fishes is full of interest, and is so important that it must be read in full with the help of the six excellent charts which Mr. Johnstone has drawn up.

The general object of the investigation described in the "Report on Measurements of Plaice" is to provide data for a study of the utility of trawl-mesh restrictions, for a more exact knowledge of the variation in the size of the fish on the various grounds and at various seasons, and indirectly for a study of the times and routes of migration. The importance of carrying out such an enquiry must be obvious to all readers, and this is one of the lines of investigation that could with great advantage be extended, both in area and in the number of data, if the resources at the disposal of the Fisheries Committee were augmented by a substantial Government grant. The research which Mr. Johnstone has undertaken is a difficult and a complicated one, as even a glance at the pages of his report will show, and one which can only be followed with full appreciation by those who have already some acquaintance with the subject; but it is quite certain that this kind of investigation, combined with a study of the statistics of the local fisheries, will be of very great value in the future in relation to the determination of the best regulations which will lead to a profitable exploitation of our fishing grounds.

In conclusion, I wish to say once more that it is much to be regretted that it has recently been found necessary to curtail the scientific work carried out by the steamer. The "Hensen" net observations, formerly taken periodically by Mr. Scott, have been abandoned for the present—until, in fact, an adequate subsidy in aid of the scientific work can be obtained from some Government source. Two of the lines of stations along which hydrographic observations were formerly made have now had to be given up, and the cruises have this year been made at intervals of three months in place of every six weeks as in 1909. It is to be hoped that these interruptions to the scientific work are only of a temporary nature. Application has been made to the Commissioners under the Development Act for a grant that will enable work of this kind, of a scientific nature bearing on the advancement of our knowledge of the sea-fisheries, to be carried on; and, if an adequate subsidy from that source can be obtained, it will place our various lines of investigation on a firmer basis, and allow of their being extended in scope and usefulness.

W. A. HERDMAN.

Fisheries Laboratory,
University of Liverpool,
April 3rd, 1911.

FISH HATCHING AT PIEL.

By Andrew Scott, A.L.S.

The fish hatching operations carried on at Piel in the spring of 1910 produced results very similar to those of past years. The adult plaice were obtained, as usual, by trawling late in the previous autumn in the closed portion of Luce Bay. Our thanks are again due to the Fishery Board for Scotland for granting permission for our fisheries steamer to fish in this protected area. The flounders were caught in the vicinity of Piel during the winter months by the police cutter stationed in the Northern division of the Lancashire district.

The flounders commenced to spawn on March 10th, when 100,000 eggs were collected, and during the next three weeks the numbers increased rapidly. The first fertilised eggs of the plaice were not obtained till March 21st. This was twelve days later than in 1909. There appears to have been a general lateness in the fish spawning in the Irish Sea in the spring of 1910, as we had considerable difficulty in getting nearly mature female whiting for dissection in the classes. The Hensen net collections were completed on March 7th, and the steamer proceeded on the following day to the fishing grounds lying between Lancashire and the Isle of Man to trawl for round fish for the class then assembled. It is in this area that one of the most important spring fisheries of the Irish Sea is carried on by the steam and sailing trawlers. The townet was used continuously to obtain surface organisms while the trawl was fishing along the bottom. Although collections were made over a considerable portion of the fishing area lying to the North of Morecambe Bay Light Vessel during nearly six hours, the total volume of fish eggs obtained at the end of this period measured only about five cubic centimetres. Only the eggs of cod, whiting and dabs were present and the larvae were just beginning to develop. On March 6th, 1905, the same area was in a very different condition, and the surface organisms consisted of little else than fish eggs. The tow-net was taken in at intervals of ten minutes for an hour and its contents roughly examined. Every time the net was hauled we saw at a glance that it contained large numbers of fish eggs with the larvae in all stages of development. These eggs represented plaice, dab, flounder, haddock and whiting. Of course it ought to be remembered that this remarkable abundance of eggs in 1905 may have been purely local, and represented the massing set up by influence or absence of winds and currents. There is no doubt that the animal life of the sea is subject at certain times to great and sudden increases due to the setting free of eggs and free-swimming larvae from adults that may be present at the bottom. A few female cod, haddock, whiting, flounders and plaice will liberate large numbers of eggs in less than a couple of weeks when they are spawning. The common barnacle, that is so abundant on almost every coast, sets free its whole progeny (3,600 to 9,000, according to the age of the parent) in twenty-four hours as active free-swimming larvae. The eggs and larvae set free rise towards the surface to be dispersed in all directions by winds and currents. Where adults are scarce the pelagic embryos will no doubt be proportionately scarce. When it is found, however, that the eggs of fish, for instance, are less developed under natural conditions than at a corresponding date in a previous year, one may be justified in concluding that there has been some retarding influence in spawning which has also affected spawning fish in confinement.

The following tables give the number of eggs collected and the fry set free on the dates specified:—

Plaice (*Pleuronectes platessa*, Linn.).

		Eggs Collected.	Fry Set Free.			
March 21	...	45,000	40,000	...	April	11
,, 23	...	65,000	57,000	...	,,	,,
,, 26	...	80,000	70,000	...	,,	15
,, 28	...	90,000	79,000	...	,,	,,
,, 31	...	90,000	79,000	...	,,	22
April 2	...	95,000	84,000	...	,,	,,
,, 5	...	95,000	84,000	...	,,	29
,, 7	...	95,000	84,000	...	,,	,,
,, 11	...	90,000	79,000	...	,,	,,
,, 13	...	85,000	75,000	...	May	7
,, 16	...	85,000	75,000	...	,,	,,
,, 19	...	80,000	70,000	...	,,	,,
,, 22	...	75,000	66,000	...	,,	17
,, 26	...	65,000	57,000	...	,,	,,
,, 30	...	45,000	40,000	...	,,	,,
May 2	...	35,000	31,000	...	,,	23
,, 5	...	25,000	22,000	...	,,	,,
,, 7	...	10,000	8,000	...	,,	,,
Total Eggs		1,250,000	1,100,000	Total Fry.		

Flounder (*Pleuronectes flesus*, Linn.).

Date		Eggs Collected.	Fry Set Free.		Date
March 10	...	100,000	88,000	...	March 24
,, 12	...	250,000	221,000	...	,, 30
,, 15	...	350,000	300,000	...	,, ,,
,, 17	...	500,000	443,000	...	April 5
,, 19	...	650,000	580,000	...	,, ,,
,, 21	...	700,000	600,000	...	,, ,,
,, 23	...	800,000	712,000	...	,, 11
,, 26	...	850,000	757,000	...	,, ,,
,, 28	...	900,000	800,000	...	,, 15
,, 31	...	950,000	846,000	...	,, ,,
April 2	...	1,000,000	887,000	...	,, 22
,, 5	...	950,000	846,000	...	,, ,,
,, 7	...	950,000	846,000	...	,, ,,
,, 11	...	850,000	757,000	...	,, 29
,, 13	...	800,000	712,000	...	,, ,,
,, 16	...	750,000	663,000	...	May 7
,, 19	...	650,000	580,000	...	,, ,,
,, 22	...	500,000	443,000	...	,, ,,
,, 26	...	400,000	354,000	...	,, 17
,, 30	...	350,000	300,000	...	,, ,,
May 2	...	300,000	266,000	...	,, ,,
,, 5	...	100,000	88,000	...	,, 23
,, 7	...	50,000	44,000	...	,, ,,
Total Eggs		13,700,000	12,133,000		Total Fry.

Total Number of Eggs 14,950,000

Total Number of Fry 13,233,000

CLASSES, VISITORS, &c., AT PIEL.

By Andrew Scott, A.L.S.

Four classes for fishermen were held at Piel in the spring of 1910. The usual grant of money was voted by the Education Committee of the Lancashire County Council, which enabled forty-five bona-fide fishermen residing in the Administrative County to attend a course of instruction in the Laboratory. The Southport Education Committee sent four men from Marshside, and the Blackpool Education Committee again sent three men. The Cheshire Education Committee sent four men from Hoylake. Altogether fifty-six men attended the classes of 1910 to receive instruction in Elementary Marine Biology, and thirteen of them were given an efficient course in Navigation. The selected fishermen were grouped into four classes, two containing fifteen men each, and two with thirteen each, as shown by the following lists:—

First Class, held February 21st to March 4th.—Septimus Procter, Askam-in-Furness; Joseph Bird, Ulverston; J. Bouskill, Flookburgh; Richard Dickinson, Flookburgh; William Dickinson, Flookburgh; Thomas Robinson, Flookburgh; Thomas Robinson (Junr.), Flookburgh; Edward Shaw, Flookburgh; Thomas Wilson, Flookburgh; Robert Taylor, Bolton-le-Sands; Moses Aldren, Morecambe; Joseph Bell, Morecambe; Robert Hadwen, Morecambe; Walter Raby, Morecambe; Daniel Woodhouse, Morecambe.

Second Class, held March 7th to 18th.—Richard Mayor, Morecambe; John Mount, Morecambe; John Woodhouse, Morecambe; William Woodhouse, Morecambe; Richard Parkinson, Blackpool; James Rimmer, Blackpool; Robert Scott, Blackpool; Edward Abram, Banks; Samuel Abram, Banks; Peter Taylor, Banks; Peter Wareing, Banks; Charles Rimmer, Marshside; John Wright (Jacky), Marshside; Robert Wright (Hobby), Marshside; Thomas Wright (John's), Marshside.

Third Class, held April 4th to 15th.—Robert Arnold, Thomas Bond, Frank Brunton, John Iddon, John D. Iddon, George Meikle, Thomas Newby, Allan Randles, John Sandham, Thomas Sandham, Arthur Shuttleworth, Patrick Slavin, Thomas Stoney, Fleetwood.

Fourth Class, held April 18th to 29th.—John Burrow, Flookburgh; William Stackhouse, Bolton-le-Sands; Richard Braid, Overton; John Bell, Morecambe; James Parkinson, Morecambe; Richard Ainsworth, Knott End, Fleetwood; John Abram, Banks; Robert Brookfield, Banks; Ralph Brooks, Formby; Douglas Bevan, Hoylake; William Eccles, Hoylake; Frederick N. Evans, Hoylake; Herbert Jones, Hoylake.

In the first, second and fourth classes the instruction given was the same as in former years, and had special reference to the structure, life and habits of the more important economic fish and shellfish. The success of the first Navigation class that was held at Piel in 1909 justified the continuance of the scheme, and another class on similar lines was conducted in 1910. The third class was selected for this special course, and was attended exclusively by deep sea trawl fishermen residing in Fleetwood. The morning lesson, lasting two hours, dealt with Marine Biology. It was slightly modified to suit the deep sea trawlers, and some of the common shore types were omitted. The afternoon lesson, lasting three hours, was conducted by Captain E. Barker Thornber, the County Navigation Instructor. The instruction given each afternoon prepared the students for the Board of Trade examination for certificates as second hand or skipper of a fishing vessel, and also, if any of them desired to go further with their studies, for the Home or Foreign Trade certificates as Mate or Captain. The teaching was most efficient, and the results were even better than in 1909. Five of the students immediately after returning to Fleetwood proceeded to their examination and secured certificates. This further success of the Navigation course led Dr. Jenkins to suggest that two similar classes should be held in 1911, and this suggestion has been adopted.

The usual thanks to the Sea-Fisheries Committee and to the various Education Committees who granted the studentships were given by the fishermen attending each class.

Classes for first, second and third year courses in Nature Study for school teachers were carried on simultaneously during the month of April. These classes were organised by the Barrow Education Committee with the permission of the Chairman of the Sea-Fisheries Scientific Sub-Committee. They were attended by twenty-three teachers from the schools in Barrow. The classes met in the evenings during the week, and on two Saturday afternoons.

The annual visit of inspection of the classes by the Members of the Sea-Fisheries Committee and of the various Education Committees of the County took place on April 27th. Short addresses dealing with the educational work of the Committee were given by some of the visitors. The Members of the North Lonsdale Naturalists' Field Club, Ulverston, and several of the Barrow rambling clubs paid visits to the laboratory on the Saturday afternoons during March and April.

Dr. H. H. Hoffert, one of H.M. Divisional Inspectors of Technical Institutes and Evening Schools, and Mr. A. Harris, Inspector of Evening Schools for the district, along with Mr. J. P. Laws, another of H.M. Inspectors of Evening Schools, made an inspection of the teaching work that was being carried on and also of the equipment of the establishment. Professor Bunji Mano, Tokyo Imperial University, Japan, came to the laboratory in August and made enquiries regarding the system adopted by us in carrying on the classes for fishermen and school teachers.

Our thanks are due to the United States Fisheries Department; the Smithsonian Institution; Mr. E. W. L. Holt, the Scientific Adviser to the Irish Fisheries Department; and others for further additions to our library. A very fine enlargement of a photograph of the late Mr. John Fell, the first Chairman of the Sea-Fisheries Committee, has recently been presented to the Laboratory. This has been framed and placed on one of the walls of the class room.

INTERNAL PARASITES AND DISEASED CONDITIONS OF FISHES.

By Jas. Johnstone.

(with five plates.)

Contents.

(1) Paracotyle caniculae, gen. et sp. nov. (Pl. I.)

This Trematode inhabits the head of the Common Dogfish, principally in the region of the gill slits. It was first found by Mr. A. Scott, when trawling from the S.S. "John Fell," in the Irish Sea, south from the Calf of Man, in June, 1905; and a preliminary description was given in 1906.* It was regarded then as a species of *Epibdella*, but there were some notable differences from the characters diagnostic of that genus, and as only two or three specimens were obtained Mr. Scott left the animal unnamed. During the last two years, however, the species has occurred in large numbers on the dogfishes living in the Aquarium tanks at the Port Erin Biological Station, and this abundance of material has enabled me to give an adequate description. I am indebted to my colleague, Dr. W. J. Dakin, for fixing and preserving specimens for detailed histological examination. The species appears to be new to science, and I describe it here as *Paracotyle caniculae*, with the following diagnosis:—One anterior sucker, terminal or sub-terminal, leading into a vestibule, or prepharynx, into which opens the pharynx. Posterior

*A Scott, "Faunistic Notes." *Ann. Rept. Lancashire Sea-Fish. Laby.* for 1905; p. 48, Pl. VII, Fig. 1. Liverpool, 1906.

sucker relatively small, and without radial thickenings or chitinous hooks. Intestine with two branches, and without lateral diverticula. Genital opening common, in the middle line immediately behind the pharynx. Vagina single and unpaired, opening on the ventral surface to the left of the common genital aperture. Testis single. One to two millimetres in length.

The specimens taken from Dogfish caught in the open sea were larger than those inhabiting the Port Erin tanks. I give measurements from the former examples, but the ratios of the dimensions of the various organs to the length of the body are the same in both series of specimens.

Length : 2 mm. ; Breadth : 1·2 mm.
Transverse diameter of anterior sucker : 0·14 mm.
Transverse diameter of posterior sucker : 0·3 mm.
Transverse diameter of pharynx : 0·23 mm.
Transverse diameter of cirrus sac : 0·25 mm.
Diameters of ovary : 0·35 × 0·32 mm.
Diameters of testis : 0·5 × 0·23 mm.
Mature, shelled eggs were not seen.

The body of the animal is flattened dorso-ventrally, and is elliptical in shape. In fixation it usually contracts, so that it becomes arched in the longitudinal direction, and with the convexity dorsal. This leads to some degree of distortion, and the relationships of the various organs in the preserved specimens are not exactly similar to those in the worms examined in the fresh condition. All the specimens so far seen are evidently immature.

The Suckers.

There are no lateral suckers or other accessory organs. The anterior sucker is elongated transversely, and its opening may be very different in shape. Usually it is ventral in position, as in Text-fig. 1, but it may be situated at the extreme anterior margin of the body, as in Pl. I. The opening in the anterior sucker leads into a relatively narrow passage, which is the vestibule, or pre-pharynx.

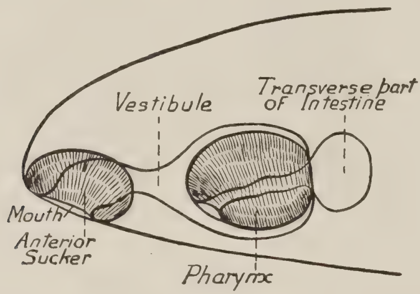


FIG. 1. Diagrammatic longitudinal section through anterior part of body.

The posterior sucker is relatively small—smaller than in species of *Monocotyle*, but larger than in *Pseudocotyle*. It is simple; raised up only slightly from the general ventral surface; and possesses no radial ridges nor hooks of any kind. It is quite terminal in position.

Alimentary Canal.

The vestibule expands to form a relatively large cavity in the anterior and median part of the body, and in this is situated the pharynx. The latter is nearly globular in shape, being only slightly elongated in a transverse direction. It lies, for the most part, freely in the vestibule, and only its posterior margin is continuous with the membrane lining the latter. Strong muscles are inserted in its posterior surface, and originate in the dorsal integument behind the pharynx. Probably the latter can be extended, as a whole, through the vestibule and the opening of the anterior sucker, although I have not seen this condition. The cavity in the pharynx is complex in shape, but very usually presents a triradiate appearance in horizontal sections of the worm. The muscular wall of the pharynx is very complex, and I do not propose to describe it here. At the posterior end this muscular wall thins out, and the cavity of the pharynx becomes continuous with that of the intestine. There is no oesophagus, and the pharyngeal lumen is directly continuous with that of the part of the alimentary canal which crosses the body transversely from behind the one excretory vesicle to the other (Pl. I). At the two latter places the intestine bends backwards as the two longitudinal rami. The latter are not straight, but are thrown into double S-shaped curves. There are no lateral pouches nor diverticula of any kind, and in this respect the species here described agrees with *Monocotyle*, but differs from *Pseudocotyle*.

The epithelium lining the intestine is represented in Pl. II, figs. 3, 4 and 5. It belongs to a type of intestine found in the genera *Microcotyle*, *Axine*, *Octocotyle*, *Diclidophora*, *Hexacotyle*, and *Octocotyle*, as opposed to the kind of intestine found in *Tristomum*, *Epibdella*, *Monocotyle*, *Callicotyle*, and the *Gyrodactylidae*,* so that this species departs from *Monocotyle* in this respect, and approximates to the Tristomidae. In most Distomes the epithelium lining the intestine consists of a continuous layer of cells, cubical or cylindrical, resting on a basement membrane. In other forms, however, the cells are partially isolated from each other, are amoeboid or are highly extensile, and have no apparent cell membranes. This is the case in the present species, where the intestinal wall consists of an irregular layer of cells resting on a

*See S. Gotto, "Studies on the Ecto-parasitic Trematodes of Japan." *Journ. Coll. Sci. Imperial University Japan*; Vol. VIII, pt. I, p. 58; Tokyo, 1894.

very thin structureless basement membrane, or simply on an obscurely differentiated part of the ordinary mesenchymal tissue. Fig. 3, Pl. II, represents a very usual condition, in which the cells are rounded and lie closely together, but not at all arranged in the manner characteristic of a true epithelium; the height of these cells measured from the basement membrane is 0·014 mm. Sometimes they are more separated from each other than the figure indicates, being still roughly globular in form. Sometimes they are columnar, and are arranged in a manner very similar to that seen in some Triclad Turbellaria;* and cells of this kind are represented in figs. 4 and 5. They are elongated at right angles to the length of the intestine, or they may lie along the surface of the latter. The smaller rounded or globular cells are probably such as are not actively engaged in the absorption of food matter, and their protoplasm is denser than in the more elongated cells. The latter are generally club-shaped, the rounded, globular ends projecting freely into the lumen of the intestine. Sometimes they present knob-like protuberances on their sides, and suggest that they may execute amoeboid movements for the purpose of taking up food particles. The extreme of this form of cell is represented in fig. 4, where the proximal part of the cell is seen to be drawn out to form a long pedicel, constricted in two places, and terminating distally in a club-shaped enlargement; the length of this cell is 0·07 mm. In these columnar, or club-like cells, the terminal parts usually stain lightly, as if they were occupied with large vacuoles containing non-staining matter. In all types the nucleus, which is of the usual form, is situated at the base of the cell, and the proto-

* See Schneider, *Lehrbuch Vergleichenden Histologie*, Jena, 1902; Fig. 321, p. 304.

plasm is denser here and stains more deeply. In all cases a recognisable cell membrane appears to be quite absent. The distal cell protoplasm is very finely granular, and stains light red with methyl-blue-eosin; and it contains no inclusions except small dense black bodies. It is, however, possible that some of the latter may be situated on the outsides of the cells.

This kind of lining persists throughout the entire length of both intestinal rami.

Unicellular gland structures are present outside the intestinal wall, and in the mesenchymal tissue, but these are not abundant, nor do they present any features of much interest. At the anterior extremity of the body, however, there are two groups of cells which may be mentioned. These lie near to the excretory vesicles, ventral and anterior to the latter, but they are not definitely circumscribed. They are represented in fig. 2, Pl. II (which shows part of a horizontal section of a worm fixed in Zenker's fluid, and stained with methyl-blue-eosin) by the coarsely granular structures. They lie closely together, and though many of them are pear-shaped they do not usually seem to be provided with efferent conducting portions: the longest of these granular cells is about 0·019 mm. But on tracing the group of cells in horizontal section from dorsal to ventral one comes to a plexus of thread-like anastomosing structures, which lie approximately in the same general plane and end by piercing the wall of the vestibule between the pharynx and anterior sucker. These are doubtless continuations of the pointed ends of the cells, and the secretion of the latter probably passes along them to be discharged into the vestibule. The cells and plexus have the same general structure (both are shown in fig. 2, Pl. II), and they stain a deep red with methyl-blue-eosin, and appear to be crowded with coarse granules. They might be (and probably have been in other Trematodes) called salivary gland cells. and this name is as good as any other, though we have not, of course, any direct evidence that they pour a digestive secretion into the vestibule.

I have not seen anything like the "sticky glands" mentioned by Gotto* as occurring in *Monocotyle ijimae;* but everywhere in the animal, just beneath the muscular integument, are cells, which one may loosely call sub-cuticular. In the region of the pharynx and anterior sucker, these cells are larger and more numerous than elsewhere. They are rather smaller than the mucoid cells described above, and they stain quite differently, taking a purple coloration from methyl-blue-eosin instead of a full red. They appear to send prolongations towards the integument, and one can sometimes see delicate canals piercing the latter. I think it is groups of these modified sub-cuticular cells that are described by Gotto as the sticky glands.

The Male Genital Organs.

Testis. There is only one testis in the species here described, and this condition causes the species to occupy an isolated position among Tristomidae and Monocotylidae. The testis is situated immediately behind the ovary, and is elongated transversely. In sections there are indications of the existence of transverse connective tissue partitions, but there is no doubt that the organ is a single one. In cleared preparations one sees cords or groups of testicular follicles arranged serially, but the study of sections seems to show that the follicles within the

**Op. cit.*, p. 38.

wall of the testis are isolated from each other, and are supported only by a loose connective tissue stroma. The *Vas deferens* leaves the testis from the right anterior border of the latter. Of vasa efferentia I can find no trace, though these vessels are most difficult to follow in serial sections, and they may possibly be contained among the tissue called a stroma. But it is more likely that the ripe spermatozoa are dehisced into the general cavity of the testis, and so find their way into the vas deferens. The latter vessel runs forward to the right of the ovary and uterus, between the latter organs and the right intestinal ramus. Near the posterior margin of the cirrus sac the vas deferens becomes convoluted. It is a fairly wide vessel, which is everywhere filled with spermatozoa. There is no vesicula seminalis or other enlargement on the course of the vas deferens.

Cirrus and Cirrus Sac.

The cirrus sac is the most anterior of the three organs seen behind the pharynx. It is a large, thick-walled vesicle, pointed anteriorly in horizontal sections, and egg-shaped in longitudinal sections, with the pointed end ventral. Its wall is strongly muscular, and consists of two series of fibres, circular fibres running parallel to the horizontal plane of the worm, and completely round the sac; and longitudinal fibres, which originate in a cuticularised part of the wall of the sac at its ventral extremity, and run round it in a direction parallel to its axis. Both series of fibres are represented in fig. 2, which is a section of the cirrus sac taken at right angles to its principal axis. In this figure they are represented by the dots, while the circular fibres are represented by the concentric lines. Other fibres, muscular and tendinous, pass out from the wall of the sac, and are attached to the adjacent ventral integument: these hold the organ in position.

The cirrus sac contains the intromittent organ—cirrus or penis. The vas deferens pierces the right wall of the sac, and then runs ventrally as a tube of restricted diameter. Near the ventral border of the sac it turns

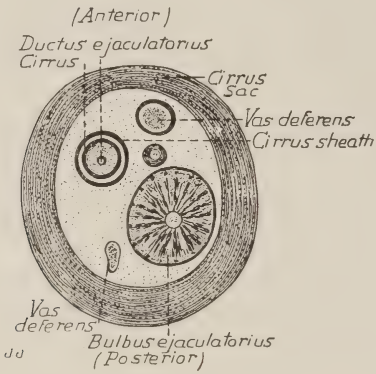


FIG. 2. Section of the cirrus sac passing transversely to its long axis.

round to the anterior wall, and then runs dorsally and posteriorly (Pl. I and text-fig. 3), enlarging considerably in diameter and lumen, and constituting a seminal reservoir. Near the posterior border of the sac it opens into the bulbus ejaculatorius. This is a cylindrical body, rounded at either end, and lying in the posterior part of the cirrus sac, roughly parallel to the axis of the latter. The vas deferens enters it on its antero-dorsal margin, and the wall of the vessel now changes in character, becoming more cuticular in appearance. The wall of the bulbus is made up of fibres which appear to be muscular, but nevertheless have not the precise appearance of such. They run radially, being inserted at either extremity into the structureless membranes which form the inner and outer walls of the bulbus. There are no other fibres in the latter than these, and it is somewhat difficult to determine what part they play in the emission of the semen, which is presumably the function of the ejaculatory bulb. Possibly they only act in dilating the latter, so that it becomes filled with spermatozoa from the vas deferens. The contraction of the wall of the cirrus sac will then cause an increase of pressure of the contained

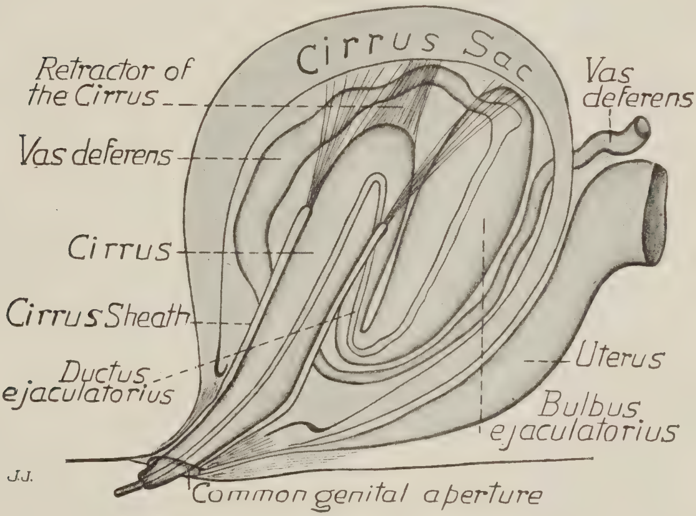


FIG. 3. Diagrammatic longitudinal section of the cirrus sac.

fluid, and this will be exerted on the outer wall of the bulbus, thus causing an emission of the semen from it, at the same time as the penis is extruded.

The lumen of the ejaculatory bulb is continued as that of the ductus ejaculatorius. The latter is a narrow tube with firm, hard, "chitinous" walls. Leaving the ventral end of the bulbus it turns dorsally, being surrounded with fibrous connective tissue running mostly longitudinally with regard to the ductus itself. The tube then turns round ventrally again, and runs as the axial structure of the cirrus.

The latter, which is the actual copulatory organ, is a cylindrical body tapering distally, and situated in the anterior half of the cirrus sac, lying nearly dorsoventrally. Its lumen is very narrow. Its internal and external walls are composed of the same "chitinous" substance as makes up the rest of the wall of the ejaculatory bulb. The penis is relatively thick, and the greater part of its wall between the limiting membranes is made up by a very dense connective tissue substance, consisting apparently of fibres running parallel to the ductus. The latter may project beyond the extreme tip of the penis.

The greater part of the latter is contained within a sheath which is a reflection inwards, through the genital aperture, of the cuticular wall of the body. The sheath is continuous with the outer limiting membrane of the cirrus itself. Obviously the sheath is inverted when the cirrus is extruded through the common genital aperture in copulation. Two series of muscle fibres are connected with the cirrus and its sheath. One series (see fig. 3) originates in the inner wall of the cirrus sac, and is inserted round the cirrus at its marginal parts next to the sheath. The other series (possibly both may be the same) is inserted into the central part of the penis.

The Female Genital Organs.

The *Ovary* is situated very near the central part of the body, immediately anterior to the testis, and with its posterior surface in close contact with the anterior surface of the latter organ. It is an oval body elongated in the transverse direction. At its anterior side, and a little to the left there is a prominent protuberance from which the oviduct takes origin. The wall of the ovary consists (see fig. 6; Pl. II) of a structureless basement membrane, lined internally with an irregular layer of cells. The ova are formed by proliferation from this layer. Internally there is a loose, indefinite connective tissue stroma, as in the case of the testis: traces of this are represented in the figure. Posteriorly the ovarian cells are smaller, and are more densely compacted than in the anterior part of the organ. It is clear that we are dealing, in all the specimens seen, with only one phase in the maturation of both ovarian and testicular cells, and what the earlier phases may be we can only conjecture. Obviously earlier stages in the development of the testis might afford a clue to the possibly multiple nature of this organ.

The oviduct runs towards the right as a narrow, thin walled tube, and immediately after leaving the ovary it doubtless receives the seminal canal proceeding from the receptaculum seminis, but I refer to this point later on in dealing with the vagina. The oviduct also receives here the vitelline duct, a rather narrow tube. It then turns slightly backwards, and here the cells composing the shell gland open into it on all sides. The oviduct now enlarges considerably in diameter, becoming the uterus, and turns forwards, dorsally, and then ventrally, making a single arched bend. It then expands still further, and runs ventrally again (see fig. 3) along the posterior border of the cirrus sac. Near the ventral surface of the latter the uterus contracts very greatly in diameter, so much so that it is difficult to follow it in serial sections, and runs forward as a very fine tube which opens into the common genital cloaca. The female genital opening can be seen in fig. 3 immediately behind the tip of the penis. I have represented the uterus in Pl. I as containing eggs, but there are none of these in any of the specimens seen.

Again, one must remember that we are dealing with a protandrous hermaphrodite animal in the functional male phase.

The ova seen in the ovary are all obviously immature, and I do not give dimensions. Some are represented in figs. 6 and 7, Pl. II, and it will be seen that they are of the usual type. They are contained chiefly in the anterior part of the ovary.

The Vagina.

There is only one vagina in this species, and it lies on the left. The external vaginal aperture is a slit, elongated in the longitudinal direction, and is situated in nearly the same plane as the common genital aperture. This leads into a narrow tube, which can be traced backwards with little difficulty in cleared preparations (it is well shown in Mr. Scott's figure*) and in serial sections. The whole organ is small, and it is represented both in Pl. I and in text-fig. 4, which shows part of a horizontal section passing through the vagina. The wall of the organ consists of outer and inner limiting membranes composed of the homogeneous "chitinous" material, which enters into the composition of the walls of almost all genital ducts in Trematoda and Cestoda alike. But the posterior part of the vagina expands considerably, and here one would expect to find a large, thin-walled vesicle acting as a receptaculum for the semen received during copulation. Instead of this we find that the calibre of the tube does not increase at all, and that the dilatation is caused by a relatively enormous development of muscular tissue round the proximal part of the vagina, but certainly forming an integral portion of its wall. There are two series of fibres (fig. 4), a strongly developed

* Scott, *loc. cit.*

circularly-running series, looking like an elongated sphincter, and a strongly developed radial series, the fibres of which run from the internal to the external wall. There are no longitudinal fibres.

All this is very easy to make out, but it is exceedingly difficult to make sure of the connection of the vagina with the rest of the female organs. It will be seen from fig. 4 that some denser tissue lies in the axis of the vagina beyond the apparent termination of the lumen. Now, if one uses an oil immersion lens it is easy to see that this

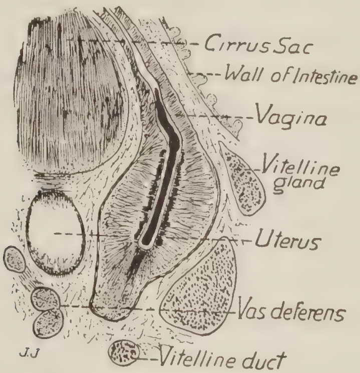


FIG. 4. Part of a horizontal section passing through the vagina.

denser tissue represents a capillary tube, which runs backwards or laterally and pierces the wall of the enlarged vagina. Beyond this various coils of the (presumably) same very narrow tube can be seen, but it is difficult to connect them and follow their course: a complete coil may be contained in the thickness of one section; and I cannot be sure whether they open into the oviduct, or vitelline duct. It is fairly certain, however, that we are dealing here with a true seminal canal; that the dilatation of the vagina represents a true receptaculum seminis; but that the animals have not entered upon the phase in their life-history when the vagina becomes a functional organ. None of those seen have been impregnated, and the substance contained in the lumen of the vessel is not semen, but a colloid of some sort, probably only mucus. It is difficult to believe that copulation takes place through the very narrow tube forming the termination of the uterus, though this may conceivably occur, and not *per vaginam*. It is, of course, possible that the latter structure may not be functional in this species, but it is highly unlikely that this condition exists. The muscular tissue round the receptaculum seminis offers yet another difficulty: it is too strongly developed not to be of some use; and it appears to me to be likely that the receptaculum may be muscular, in the functional female phase, and that spermatozoa received from another animal may be stored within it, and ejected when required into the oviduct. Obviously, these and other questions must await solution until material in other stages of sexual growth are obtained.

A genito-intestinal canal does not apparently exist in this species.

The Vitellaria

The vitellaria are very conspicuous structures in this species. They vary somewhat, both in degree of development and distribution in the specimens examined. In the worm figured they are present as a single layer of rather large follicles, situated marginally, and mostly external and dorsal to the rami of the intestine. The follicles are pear-shaped, and the stalked portions of two or three adjacent ones usually fuse to form ducts of the second order, which open into the longitudinal collecting vessels. In the specimen figured (one of the larger worms collected in 1905 by Mr. Scott) there are only two main longitudinal ducts, one on each side, and these receive the ductules from the follicles directly. Posteriorly the duct of the right side bifurcates, and the internal branch collects from a median unpaired group of follicles situated immediately behind the testis. In a specimen collected at Port Erin, and stained with methyl-green by Mr. W. Riddell, the arrangement was slightly different. The longitudinal duct of the left side bifurcated at about the transverse plane passing through the ovary, and the two branches so formed served the follicles of the left side. The right duct bifurcated at about the same place and then passed posteriorly and medially collecting from the little median posterior group of follicles. In this specimen the follicles were relatively smaller than those represented in Pl. I, and the individual ductules from them were relatively longer. The variations noted are probably dependent on the degree of development.

The longitudinal collecting ducts enlarge, notably at the external margins of the ovary, so that yolk reservoirs are formed. From each of these a transverse duct passes inwards, and these unite near the middle line of the body, and from this common transverse duct a short, narrow vessel passes backwards and to the right, and opens into the oviduct, between the ovary and the shell glands.

Fig. 1, Pl. II, represents a horizontal section through one of the follicles of the vitellarium. The latter is about 0·4 mm. in longest diameter.

The latter is bounded by a very thin limiting membrane, the structure of which appears to be quite homogeneous. Within this are a number of cells in all stages of development with regard to their yolk contents. The smallest cells are situated round the periphery of the follicle in small groups: these cells are usually slightly flattened out, have a dense cell substance staining deeply with methyl-blue-eosin, large nuclei, with very prominent nucleoli. In slightly larger cells there are one or more clear spaces, like vacuoles, but really accumulations of non-staining yolk material, and the nucleus is still placed centrally. In larger cells still, the number of these spaces increases, and the cell substance diminishes relatively to the size of the cell. The nucleus is still central, and the yolk masses are placed symmetrically round it. The largest yolk cells are irregular in shape, and have the yolk substance still arranged in distinct rounded masses separated by narrow septa of undifferentiated cell protoplasm. Finally, the cell membrane ruptures, and the yolk granules become free in the lumina of the vitelline follicles or ducts. These granules appear to be flattened, egg-shaped bodies, relatively large in size. They do not take ordinary stains, but have a yellow-brown colour of their own.

The Excretory Vesicles.

These are two prominent vesicles, one on either side of the pharynx. They are roughly oval in shape; open by fine ducts on the lateral or ventral part of the body; and have an epithelium, cuticular, or at least structureless in nature. I have been able to trace the most proximal part of the longitudinal excretory canals, but not the entire length of these vessels.

Systematic Position.

There is great difficulty in referring these animals to any known genus of Ectoparasitic Trematodes. Obviously they are to be included among the Tristomeae, but they are not Tristomidae, for the absence of the paired accessory anterior suckers, or the replacing membrane, coupled with the absence of radial ridges, and chitinous hooks on the posterior sucker certainly places them outside this family. The only family to which they can belong is the

Monocotylidae. Taschenberg's diagnosis of this group (which I quote from Braun) includes the following characters:—Anterior accessory suckers absent; posterior sucker small, or normally developed, and with chitinous hooks; genital opening median; vaginae double and paired. But Gotto has described a species of *Monocotyle* (*M. ijimae*) in which the vagina is single and unpaired, and there are probably other species which present the same character, and all the forms described may not have been investigated in sufficient detail to make it certain that the vagina is really double. Of the genera of Monocotylidae only *Pseudocotyle* has a posterior sucker entirely devoid of radial ridges and hooks, while these are present in both *Callicotyle* and *Monocotyle*. The worm here described, therefore, approximates to the former, and diverges from the latter genera, so far as the characters of the posterior suckers are concerned.

But *Pseudocotyle* differs in that it possesses numerous testes, and has an intestine with numerous lateral branches on the rami. The original diagnosis given by van Beneden and Hesse says:—"Point de ventouses à côté de la bouche, et la ventouse postérieure du corps très variable dans sa forme comme dans la grandeur; cette ventouse ne renferme ni rayons ni crochets; le canal intestinal est ramifé" Now the branching of the intestine and the presence of numerous testes certainly constitute a fundamental difference between *Pseudocotyle* and the form now being described. It is conceivable that such a superficial character as the presence or absence of the rays and hooks in the posterior may not be a character of very great taxonomic value. If it is not, then we may identify the Port Erin worm with the genus *Monocotyle*.

In *Monocotyle* the intestine is simple, consisting of two lateral vessels, devoid of diverticula of any kind. The vagina in *M. ijimae* at least resembles very closely that which I have described above, it is small, lateral and unpaired, and opens on the left side. The testes are three in number, but are very closely apposed to each other, and a single vas efferens leaves the compound organ from the left anterior lobe. There are indications that the single testis of the Port Erin worm was formerly compound, for incomplete partitions penetrate into it. The follicles of the vitellarium are more numerous. It is possible that such differences as that between the testes and vitellaria may be of specific value only, but so far as the present classification of the Monogenetic trematodes goes one must regard the character of the posterior sucker as of generic value. In short, the nearest known genus to the form now being described is *Monocotyle*, but the approximation is not close enough to justify us in so referring it.

I propose, then, the name *Paracotyle caniculae* for the Trematode described above, and regard it as the type of a new genus and species.

Paracotyle, gen. nov.

One anterior sucker; posterior sucker small, and without radial ridges or chitinous armature; intestine without lateral diverticula; one testis; one vagina on the left side; genital aperture in the middle line.

One cannot help being impressed with the unsatisfactory state of the classification of the whole group of Ectoparasitic Trematodes, but it would, obviously, be a futile task to attempt to revise it at the present. When one considers how many new Helminths have recently been described from tropical and sub-tropical waters,* it becomes certain that the group is, as yet, imperfectly

* For instance by Gotto from Japanese seas, and by Shipley, Hornell and Lühe from Ceylon Seas.

known. But it appears to me that confusion has been created by disregarding differences which, in other groups of animals would be of generic value at least; and straining the diagnoses of the genera so as to admit species which ought to be grouped in some other manner.

(2) Koellikeria filicolle (Rudolphi). (Text fig. 5.)

Early in 1910 a specimen of *Brama raii* was obtained from the Menai Straits, and came into the possession of Professor P. J. White. This is the only record of the occurrence of Ray's Bream in the Irish Sea, though F. Day speaks of its capture in the Bristol Channel. It is a form more characteristic of the Mediterranean and Bay of Biscay than of our waters, though it also occurs as far north as the Faeroe Islands, a part of the sea with, probably, greater faunistic similarity to that of the Biscayan area than the Irish Sea, because of the intensity of the Gulf Stream Drift. The fish referred to was examined by Professor White, who then noticed some cysts on the branchial arches, and sent parts of the latter to my colleague, Mr. A. Scott. Finally, they were handed over to me.

The cysts contain the interesting Distomid originally called *D. filicolle*, then *D. okenii*, and now *Koellikeria filicolle*. It is well figured by P. J. van Beneden,* but I give a figure here. There were three cysts on the piece of gill arch sent to me, but one had been removed. These structures vary from about 25 to 12 mm. in greatest diameter. The larger cyst contains more than one pair of worms. Fig. 5 represents one of the females dissected out from the cyst: the head and anterior part of the body are filiform, but the posterior part is enlarged and kidney

* In the "Mémoire sur les Vers Intestinaux," Pl. X.

shaped. The male inhabits the same cyst, is entirely filiform, and about 5 to 15 mm. in length. Two of the males are seen attached to the branchial arch between the median and the right cysts. These males are adhering to the tissues of the host by their anterior suckers, and the females are probably also so attached.

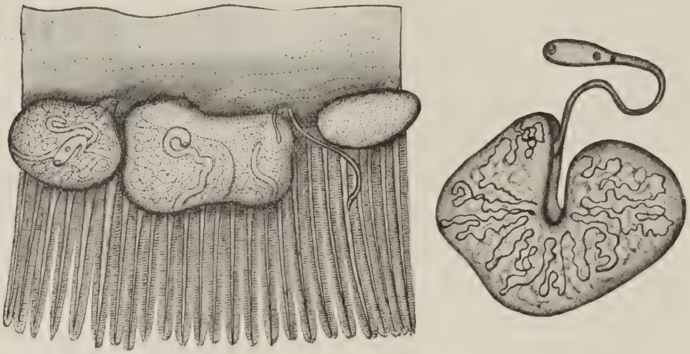


FIG. 5. Part of a gill of *Brama raii* with cysts containing *Koellikeria filicolle.* The right hand figure represents one of the parasites.

The parasite appears to be one which always occurs on the same host—Ray's Bream. Whether the sexes are separate or the animals are not really hermaphrodites it is impossible to say, in the absence of more material than has yet been obtained.

(3) PONTOBDELLA LAEVIS (BLAINVILLE).

A single specimen of a leech, which is probably the above species, was given to Capt. Wignall (who handed it to me) by Mr. F. Bailey, Inspector at Fleetwood Fish Market. It was caught by the steam trawler "Euston," of Fleetwood, off Barra, in October, 1910, and the mate, recognising that it was not the ordinary Skate-leech, put it aside.* The host was a "a very large Ray."† The leech is 26 cms. in length, and about 1·8 cms. in diameter at its thickest part, which is just in front of the oral sucker. The skin is quite smooth, green in colour‡ (after preservation in formalin), with no trace of clitellus. The segments are obscurely marked. The oral sucker is rather smaller than the anal one. The body is thinnest near the head, and increases gradually in diameter to near the anus.

(4) Various pathological conditions.

Three examples of fish tumours were sent to me during the last year, and may be worth describing.

I. Hard Fibroma.

In July, Mr. N. M. Richards, a member of the Cornwall Sea Fisheries Committee, sent me a pilchard with a tumour projecting from the alimentary canal. Apparently the condition, though rare, is not unique, for the sender had already seen "one or two" similarly affected fishes. The specimen was not in very good condition when it arrived, for the tumour had ruptured the abdominal wall, and the whole alimentary canal had "gone adrift." Fig. 6, which represents the part of the fish containing the growth, and is reproduced one-half the natural size, is, therefore, to some extent a "restoration," but is sufficiently accurate.

The tumour was attached to the alimentary canal just at the origin of the caecum, and its capsule is continuous

* Mr. Bailey has sent me further specimens recently. The hosts were *Raia clavata*, caught south-west from Ireland, off Tory Island, and off the coast of Morocco.

† Probably *R. clavata*. If it had been a *R. batis* the man would have called it a "Dunn."

‡ One specimen, obtained lately, has coloured the spirit in which it was preserved yellow-green.

with the layer of peritoneum covering the gut. The internal organs of the fish were, apparently, quite normal, and the fish itself was in good condition, well-grown, and containing the usual amount of fat. It was a mature female, with unripe ovaries. The stomach was empty, and its lumen was greatly contracted, but the caecum and all of the pneumatic duct that could be explored were full of food, copepods, and schizopods. The caecum was the thickest part of the whole alimentary canal, and appeared to me to be developed to a greater degree than is usually the case.

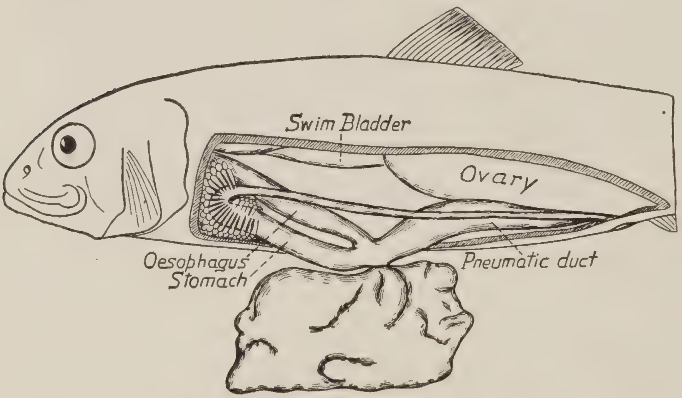


FIG. 6. Pilchard with hard fibroma on the peritoneum. ½ nat. size.

The tumour itself is about 58 mm. long, 33 mm. deep, and about 23 mm. in thickness, the various diameters being placed as in the figure. It is very irregular in shape, the whole surface being nodular, in places resembling a part of the convoluted surface of a human brain. It is very hard and firm, and has much the same consistency as a piece of soft cartilage, but is heavier. It cuts cleanly, but with some difficulty, on account of the denseness of the tissue. In liquid it has a semi-translucent appearance. It is yellow-white in colour. It becomes very translucent on clearing in xylol preparatory to imbedding and cutting, and this appearance suggested a fatty nature. The tissue did indeed contain enough fat to produce a deep brown colour when treated with osmic acid, but fat was not, however, abundant in it. Fig. 5, Pl. V, represents a small part of a section, seen under a Zeiss apochromatic 1·5 mm. oil immersion lens, and the nature of the growth is obvious. The whole structure is composed of bundles of connective tissue running in all directions. The tissue is very compact, and there are few interspaces between the fibrous bundles. The figure represents parts of two adjacent bundles, in one of which the fibres are cut longitudinally while they are cut transversely in the other. The fibres themselves are relatively thick, and polygonal, or round in section. There are very few nuclei to be seen, and the whole tumour contains very few blood vessels.

Obviously, the structure belongs to the group of hard fibromata, and has developed from the serous connective tissue of the peritoneal covering of the gut. It is obviously benign, and but for the mechanical disturbance resulting from its lodgment in the restricted peritoneal cavity it would not have affected the general health of the fish. But the wall of the abdomen covering the tumour must have become rather thin, and then pressure upon the fish must have resulted in the rupture of this wall.

II. Soft Fibroma.

The second specimen was given to me by Dr. J. H. O'Connell, to whom the fish exhibiting it was shown by a fishmonger. Dr. O'Connell cut out the tumour and preserved it, so I had no opportunity of examining the fish. The latter was a large haddock, and the growth was situated on the side of the fish behind the operculum. The tumour measures 74 by 61 by 59 mm. along its three principal diameters. It weighs 110 grams, after having been preserved in 70 per cent. alcohol for some months. It is soft, and easily deformed by slight pressure, but there is no softening or break-down of the tissue in its interior. Along one side, in the plane of the principal diameter there is a deep sulcus, almost dividing the growth into two parts. What this means, or how it has been produced I cannot say, unless the tumour may have been growing round the operculum of the fish, so that the latter was situated in the cleft. The growth was capsulated, and on slitting open the investment it dropped out. It is yellow-white in colour, and quite opaque, without any trace of the slight translucency noted with regard to the last specimen.

Sections were made, and these showed that the structure was very simple. The whole growth consists of fibrous connective tissue (see fig. 3, Pl. V), loosely arranged, and showing an obscure lamination concentric with the outer surface. The fibres are very delicate, like those present in areolar tissue, but running in relatively long, wavy bundles, between which are fairly wide interspaces. For the most part this is the only tissue present. The tumour is vascular, but not richly so; and round the blood-vessels the connective tissue fibres run concentrically, and there are small round cells in these places. Occasionally there are nests of these connective tissue cells, but such structures are few in number.

The growth belongs, obviously, to the class of encapsulated non-pedunculated fibrous tumours or "wens." It is benign in nature, and probably did not injuriously affect the health or condition of the fish, though it must have given the latter a rather repulsive aspect, certainly such as to prejudice a buyer against it, though it could have had no evil effect on the health of anyone using the fish as food.

III. Melanotic Mixed-Cell Sarcoma.

This is by far the most interesting of the three tumours. It was found by Professor Herdman in a Ray (*Raia clavata*) caught in the trammel net of the Biological Station, in Port Erin Bay, in August, 1910. From the general appearance of the fish Dr. H. E. Roaf expressed the opinion (since fully confirmed on examination of the specimen) that the growth was a melanotic sarcoma. The head of the Ray was preserved in formalin, and small pieces from the tumour and various organs were preserved by Mr. Chadwick in Zenker's fluid. Except for the deposition of mercury compounds in the tissues, due to imperfect washing out of the fixative, the preservative is all that can be desired. I am obliged to Dr. E. Glynn, of the Pathological Department at the University, for confirmation of the diagnosis of the nature of the tumour.

The Ray was evidently greatly emaciated—so much so, says Mr. Chadwick, "that the outlines of the skeleton could be distinctly seen when the fish was alive." On the right side of the head (see the photograph, Pl. III) between the eye and the margin of the body, but quite close to the latter, was a tumour, elliptical in outline; measuring 75 by 60 mm.; and raised up above the level of the skin by about 15 to 20 mm. The growth was dense black in colour, but at the edges the pigment faded away gradually into the normal grey colour of the skin. The whole growth was evidently covered by epidermis, or by a modified, infiltrated epidermis. The tumour was injured by the removal of the fish from the net, so that it is much broken in the central parts, but not so much so as to prevent one from concluding what its appearance must have been. I think necrosis has occurred in the central parts of the growth, and this was the cause of the injury.

Irregular pigment spots, varying in diameter from about 3 to 6 mm., were scattered over the skin of the anterior part of the body. Dr. Roaf thought it possible that these might represent metastatic formations, and one such piece of skin was fixed for examination. But the tissue is apparently quite normal except for a greater development of the black pigment underlying the epidermis. It is difficult to say whether or not there is any indication in these pigment spots of a commencing generalisation of the sarcoma—possibly this may be their meaning.

The liver was very soft, a condition apparently due to the formation of extensive lacunae among the hepatic tubules. The coloration is due to the deposition of melanin among the otherwise normal tissues. The pigment is present in groups of round bodies, each about twice the size of an hepatic cell. It is difficult to say now whether or not the pigment is deposited within hypertrophied hepatic cells, or whether it is contained in intrusive cells —probably the former is the true condition.

The brain, muscles, cartilage and other organs, except the spleen and gills, were quite normal. The gills are deeply pigmented with melanin.

The fully-developed tumour itself, and a small portion of its growing edge, were examined in section. Fig. 1, Pl. V, represents the general appearance of a thin section of the tumour, which has been stained in methyl-blue-eosin. Very little of its structure can be made out in such a preparation because of the density of the tissue and the deep pigmentation; and it was necessary to decolourise the sections. The pigment is very stable, being unaffected by acids, the materials used in fixation, by formalin or alcohol. It was unaffected by nascent sulphur dioxide, liberated by adding oxalic acid to a solution of potassium sulphite. It was bleached by the chlorine and oxides of chlorine liberated from a solution of potassium chlorate containing hydrochloric acid. It is not decolourised by weak alkali. It is bleached by hydrogen peroxide (commercial strength, "20 vols.") in two to three days, the deep black fading to a light yellow-brown colour. The sections bleached in acid chlorate solution were unsatisfactory since the colour appeared to return after the manipulation of the sections, and the staining reaction was not a good one. Decolourisation by hydrogen peroxide was employed in all cases prior to staining, but the tissues so bleached stained unsatisfactorily or with great difficulty. Ehrlich's haematoxylin did not act well: the blue coloration could not be obtained. Heidenhain's iron haematoxylin stained the sarcomatous cells deeply, and when they were differentiated sufficiently the adjacent connective tissues had entirely lost the stain. It was found that Mann's methyl-blue-eosin gave, on the whole, the best results, and all sections made were stained in this fluid.

Sections were cut from the fully-developed tissue, and from its growing edge. The part of the tumour fixed at Port Erin included only the developed tissue and the part of the growing edge examined was taken from the fish after it had been preserved in formalin. Curiously enough, the fixation in the latter case was not inferior to that of the tissue fixed when the fish was fresh. Fig. 1, Pl. V represents a part of the fully-formed growth stained with methyl-blue-eosin, but not decolourised in any way. Such sections allow us to see very little of the minute structure of the tissue, because of the enormous amount of deposition of melanin in the cells. The figure represents a thin part of the section, where the cells are relatively widely separated, and where the pigment is less dense than usual. Although little can be seen in such sections it is evident that we have to deal with elongated cells loaded with masses of melanin. The latter is deposited in the form of fine granules, which are individually of a brown colour, but are dense black in mass. They are so closely aggregated that, as a rule, the pigment accumulations appear to be uniform in structure. At the edges of these masses, and in places where the deposition of the pigment is only beginning, the separate round granules can easily be seen. Although the study of such sections alone would, I think, be insufficient for the diagnosis of the growth, the appearance presented by them is strikingly similar to that of the illustrations of some human sarcomata.

Fig. 2, Pl. V, represents part of a similar section to that described above, but the sections, after being mounted on the slides, were placed in commercial hydrogen peroxide for about 48 hours. The result is that the melanin is oxidised, and has assumed a light brown colour, and has become very transparent. Subsequent staining is, however, difficult, since the products of oxidation of the melanin still remain in the cells. But the spindle-shaped cells can now be clearly recognised. The latter are of very various sizes, and the largest that I measured was about 0·07 mm. in length. They are round in transverse section; usually swollen at the middle, no doubt because of the accumulation of the pigment there; and they taper at both ends and sometimes end in fine fibres. In many cases no nuclei can be seen in these cells, but this may be attributed to the difficulty of staining after the bleaching process. In other cases the nucleus has the appearance of a globular or oval space in the cell, containing light brown granules. In other cases a nucleus, exhibiting a distinct chromatic skein, can be made out. But the fixation of the tissue was not good enough to enable the nuclei to be studied without risk of error.

Between the cells is a connective tissue stroma, very variable in degree of development. Usually it is more highly developed than is represented in fig. 2, since a part of the section as free as possible from other structures than the typical sarcomatous cells was selected. The connective tissue is of the ordinary kind, consisting of fibres running for the most part parallel with the spindle cells, but forming reticular structures in the looser parts of the tumour. It occasionally contains sheets, or flattened-out coarse fibres. Small cells, with little cell substance and relatively large nuclei, are present, but are not abundant.

The tumour contains few blood vessels, and these are generally small, and are nearly always empty. Here and there a few corpuscles, usually rather distorted in shape, can be seen. The vessels sometimes contain black masses, evidently cells, or fragments of cells from the tumour, which have found their way into the lumina, probably because of the breakdown of the tissues in the central part of the growth. If, as in rare cases, the vessels contain many corpuscles, the latter are usually disintegrated.

The spindle cells are usually arranged so that they lie side by side, presenting the appearance of bands in the section. Fig. 2 represents a small part of one of these bands, or rows rather, of spindle cells. There is relatively little connective tissue between the cells, but between the various rows of cells there is considerably more; and this takes the form of fibrous tissue with corpuscles (see the bottom of fig. 2). The rows of spindle cells run in all directions, so that the cells themselves are sometimes cut in transverse section; but among them there are other smaller spindle cells lying with their long axes in the plane of the section. When the larger spindle cells are cut transversely they often appear to be surrounded by annular spaces. Small spherical cells are also present, but these are relatively few in number in the fully developed tissue.

The Growing Edge of the Tumour.

Obviously it is only by examination of the growing edge that we can be certain whether or not the tumour is malignant in nature. I think there is no doubt that this is the case with the growth in question—it is a truly malignant sarcoma. Fig. 1, Pl. IV, represents a vertical section of the skin of the Ray at a distance of about two inches away from the tumour: the region of the skin from which the section was made can be seen in the photograph (Pl. III) and also the region of the edge of the tumour itself which was examined. The structure of the skin of an Elasmobranch fish is well known, but I reproduce an original drawing for the purpose of comparison with the affected area. The epidermis is rather thick, and consists of cells roughly columnar in shape at the base of the layer, but polyhedral in shape nearer to the surface. The cells are "prickle-cells," that is, they are joined together by delicate protoplasmic filaments. Sometimes the cells are very closely apposed, but the filaments can nearly always be seen. The epidermis rests on a thin layer of areolar connective tissue, and just underneath the bases of the cells forming the lower boundary of the epidermis there is an interrupted layer of black pigment cells. These occur everywhere in the skin of the fish, and in the black spots on the anterior part of the fish—the possible metastases—this layer of pigment is developed to a greater extent than elsewhere. The epidermis contains numerous goblet mucous cells, represented by the small elliptical white spots in the figure.

Directly beneath the epidermis, and piercing the latter, are the scutes of the skin: a part of the flattened base of one of these structures is represented in the figure. The dermis, forming the lower layer of the integument consists of one or more layers of coarse connective tissue, and some areolar connective tissue. The superficial layer of the dermis consists of very coarse fibres running parallel to the surface of the skin. These fibres are wavy, are not very long, and are divided into short bundles separated by vertical connective tissue dissepiments. There are also fibres running perpendicularly to the surface of the skin, but the horizontal series is the more highly developed. The scutes are embedded in this dermal connective tissue. The superficial layer rests on a thin layer of fine fibres, and the deepest of the coarser fibres of the superficial layer of the dermis stain more deeply than the others. Beneath this fibrous "basement membrane" is another layer of coarse connective tissue fibres; then a thin layer of areolar tissue; and then another layer of coarse fibres. Beneath this again is another layer of coarse areolar tissue containing blood vessels, and the sensory canals occupy this layer of the skin. Deepest of all may be yet another layer of coarse fibres, and then we come upon the muscles of the body. Two of these muscle fibres, cut transversely, are represented in the figure. I do not suppose that this arrangement of the layers of the dermis is quite constant in every part of the skin of the fish, but it is that arrangement present in the vicinity of the tumour.

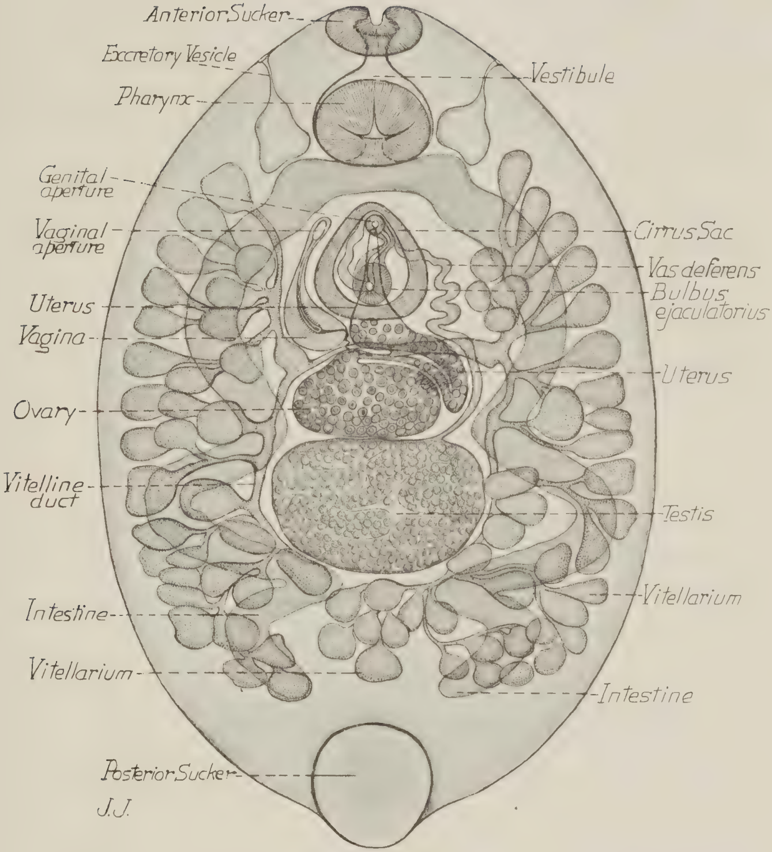
Fig. 2, Pl. IV, represents the proliferating edge of the growth, and is drawn to the same scale as fig. 1, and placed alongside the latter for the purpose of comparison. The epidermis is here quite normal, and so also are the deeper layers of the dermis. But all the tissues between the epidermis and the lower layers of coarse connective tissue fibres are infiltrated by the sarcomatous growth. Fig. 2 is drawn to a low scale, so as to show the whole thickness of the skin, and the intrusive tissue is represented by the stippled dots and the faint streaks. This tissue occurs down as far as the layer of coarse fibres overlying the muscles of the body, and it has insinuated itself between the dermal connective tissue layer and the epidermis; and between the fibres of the upper layers of the dermis. Approaching the edge of the tumour from the normal skin one finds these fibres becoming more loosely arranged. Then they become broken up into short lengths and irregular pieces, and finally disappear. Fig. 3 represents a small part of the transition zone between normal and diseased tissue, as it is seen under a high-power lens. The darkly shaded structures are the fragmented connective tissue fibres, and among these are some fibres and nuclei, probably belonging normally to this region, and the proliferated cells of the sarcoma. The latter cells vary in shape, some being globular, while others are already columnar, or spindle-shaped. All have normal nuclei (so far as can be ascertained, though the fixation leaves much to be desired in this respect); and the amount of melanin present in them is less than in the regions where the tumour tissue is more highly developed.

Fig. 4 represents the intrusive cells in the deeper areolar tissue just over the body muscles, and it is some of these proliferated cells that are figured. The cells are, for the most part, globular, but some are irregular in shape, and others present appearances indicating recent division. With regard to this point, however, the results deducible from the tissue are unsatisfactory, since no mitotic figures can be seen. A small artery is shown near the bottom of fig. 2, and round this there is an astonishing multiplication of the connective tissue cells, so that this part of the section has an appearance almost like that of the interstices of a lymphatic gland. In its proliferating zone the sarcoma is of very mixed character, and it is only in the older regions that it assumes a spindle-cell character.

Perhaps the most convincing evidence of the malignancy of the growth is afforded by a study of the epidermis over the marginal parts of the tumour. Fig. 4, Pl. V, represents a part of the normal epidermis, and is reproduced for the purpose of comparison with fig. 6, which represents a part of the epidermis covering the outer zone of the actual tumour. Here the cells of the sarcoma have invaded, and are infiltrating the superficial layer of the skin. In normal conditions the cells of the latter are in contact with each other except for the very short "prickles"; but in the invaded parts the epidermal cells become dwarfed, are separated from each other by relatively wide spaces, and the protoplasmic filaments become drawn out, or break through, so that the cells may become isolated from each other. Intercalated among them are cells which are similar to those of the tumour at its zone of proliferation; and may even be loaded with melanin granules. The epidermis gradually thins out over the older parts of the growth, and then the latter becomes more exposed to mechanical or possibly septic injury.

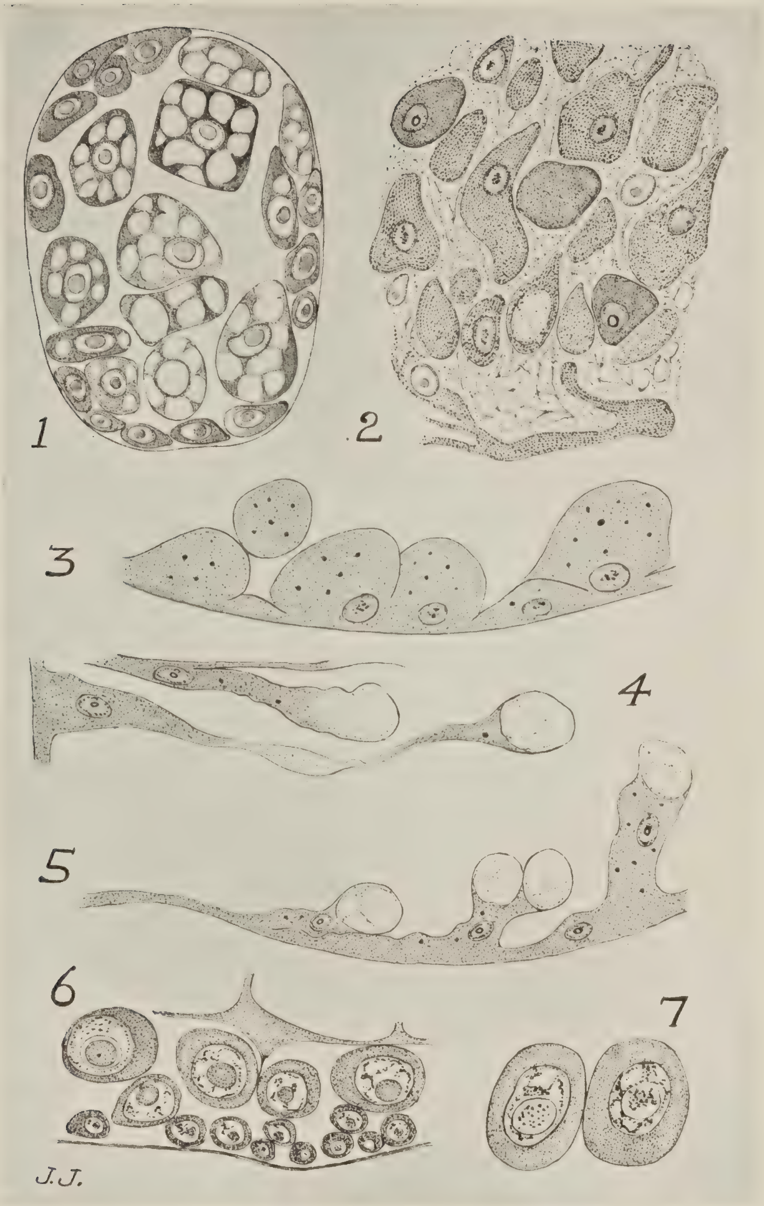
It seems quite clear that the tumour is a really malignant one, and does not belong to the class of healing or regenerative new tissues which one often finds in fishes in the neighbourhood of wounds and scars. I am glad to support this interpretation by the opinion of Dr. E. Glynn, who has had much experience in the examination of human malignant tumours, and who assures me that if it were of such origin he would not hesitate to call it a mixed-cell sarcoma. That it was malignant, with respect to the health of the fish, appears to be evident from the abnormally poor condition of the latter. Nevertheless, one would like to have convincing evidence that a sarcomatous or carcinomatous tissue pursues the same course in such an animal as in man, that is, by generalisation, so that many other organs become attacked, and the fish succumbs to it, for such growths as have been described in fish appear to be usually local ones.

The five Plates that illustrate this paper are referred to fully in the text.



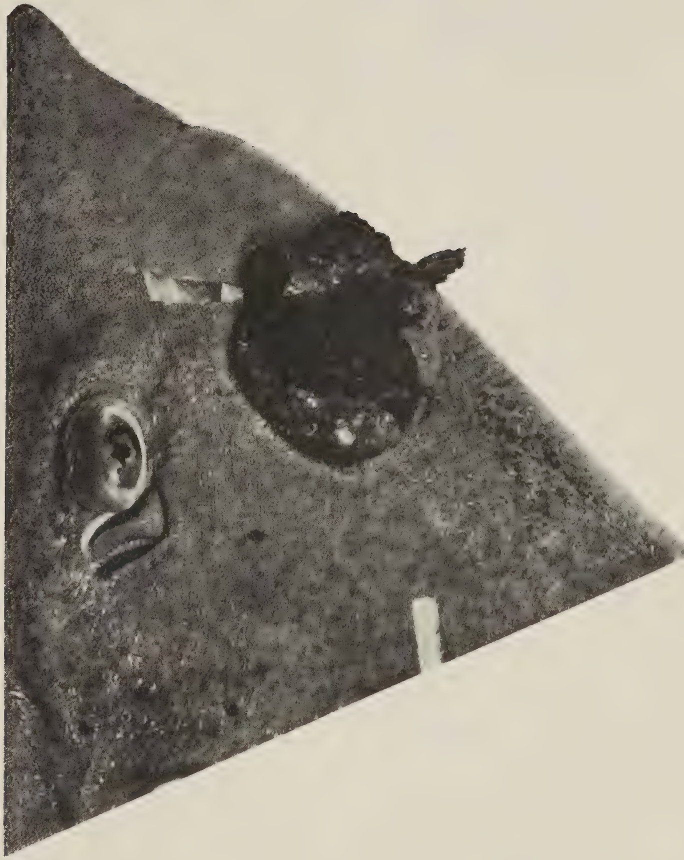
PARACOTYLE CANICULAE.

Stained and cleared preparation represented as seen from the dorsal surface. The posterior sucker is seen through the body



PARACOTYLE CANICULAE.

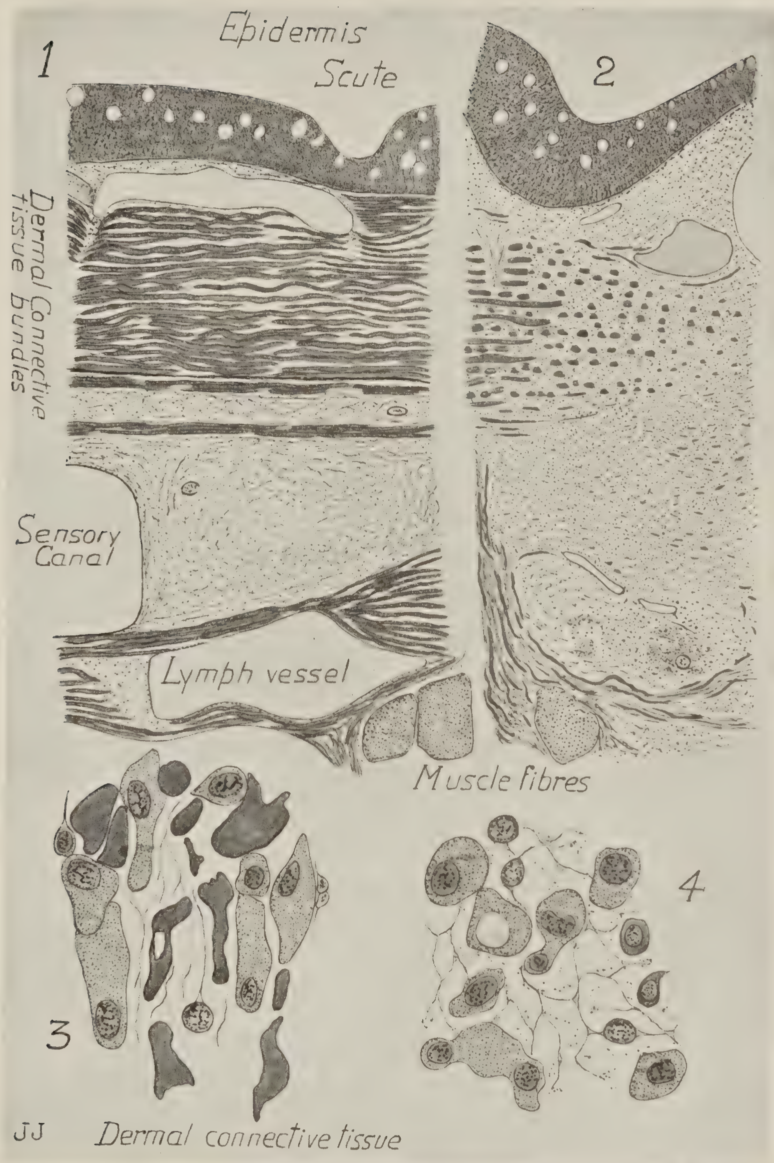
1. Transverse section of a vitelline gland follicle.
2. Mucous gland cells near the mouth.
3. Wall of the intestine.
4 & 5. Cells from the intestinal wall.
6. Peripheral part of the ovary.
7. Ovarian cells.



SARCOMA IN *RAIA CLAVATA*.

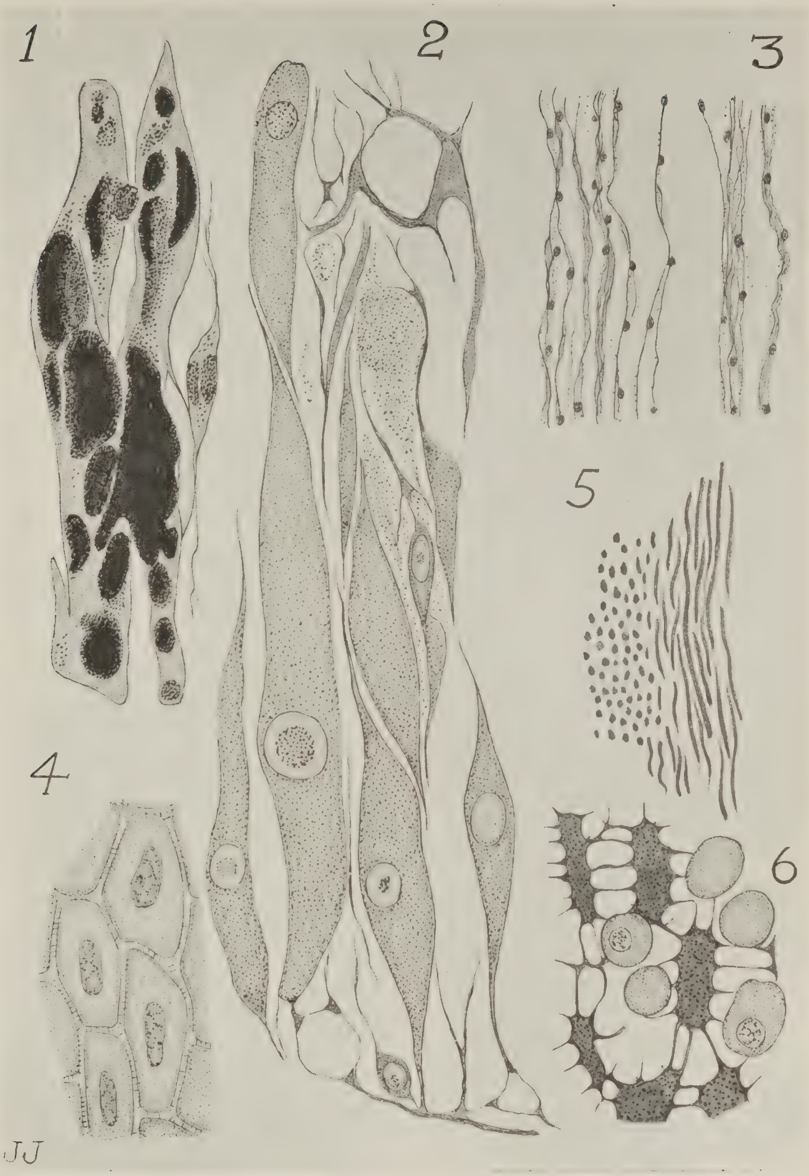
Photograph of right side of anterior part of head. Reduced.

(*Photo by A. Scott.*)



SARCOMA FROM *RAIA CLAVATA*.

1. Normal integument near tumour.
2. Integument at growing edge of tumour.
3. Altered connective tissue at growing edge of tumour.
4. Altered areolar sub-dermal tissue.



SARCOMA IN *RAIA CLAVATA*, Etc.

1. Tissue of tumour.
2. The same treated with hydrogen peroxide.
3. Fibroma from Haddock.
4. Sarcoma from Ray. Normal epidermis near tumour.
5. Fibroma from Pilchard.
6. Sarcoma from Ray. Altered epidermis over tumour.

NOTE ON A SPOROZOAN (*MEROCYSTIS KATHAE*, N. GEN. ET SP.) OCCURRING IN THE RENAL ORGAN OF THE WHELK.

By Dr. W. J. Dakin, Assistant Lecturer in Zoology in the University of Liverpool.

Whilst examining and fixing tissues for histological purposes, an interesting parasite was observed infecting the renal organ of the whelks (*Buccinum undatum*) which have been collected off Port Erin. The parasite is a Coccidian. It occurs in enormous quantities, and can be detected quite easily with the naked eye in dissections, appearing in the form of small white spherules. In sections of the renal organ as many as fifteen to twenty may appear in the field of view at once (when examining with say a $\frac{2}{3}$ in. Leitz objective), showing perhaps three or four stages in the life history. The life history has been worked out from the examination of a large number of sections, and that part of the life cycle occurring in the renal organ of the whelk represents sporogony. The earliest stages are small pear-shaped or spherical bodies which possess a large nucleus and a very distinct nucleolus One or more host cells may be infected and the hypertrophied cells extend around the parasite, with a large quantity of hypertrophied nuclear material in close contact with it. Growth appears to take place until a considerable size is attained. After fertilisation, the nucleus divides up in an extremely interesting manner. By direct division three or four nuclei are formed which go to the periphery of the parasite. These divide in turn until a number of peripheral nuclei are present. Partitions now appear in the cytoplasm until the whole is divided into segments, in each of which one or more peripheral nuclei are to be found. These continue dividing until each segment has its own peripheral layer of closely-placed nuclei. Following this stage the nuclei separate, each with a small portion of the cytoplasm. Round the spherical bodies thus formed a delicate sporocyst is secreted, and the sporoblasts become the resistant spores. In the spore the nucleus elongates until it becomes long and coiled in a very characteristic manner. A single sporozoite is developed in each spore and a mass of residuary protoplasm remains in the centre.

A detailed account of the life history, as far as at present worked out, will shortly appear in the "Archiv f. Protistenkunde."

The position of the new species is as follows:—

COCCIDIIDEA.

FAM. POLYSPOROCYSTIDAE.

Genus, *Merocystis;* species *M. kathae.*

The parasite is characterised by the division of the oocyst by septa into secondary cysts, in each of which numerous spores are formed. These all lie in the later stages loosely in the larger cyst. The sporocyst is smooth and not bivalve. The spores are monozoic.

THE HYDROGRAPHIC WORK IN THE IRISH SEA DURING 1910.

By Henry Bassett, Jun., D.Sc., Ph.D., Assistant Lecturer in Chemistry in the University of Liverpool.

For various reasons the hydrographic observations made by us in the Irish Sea during 1910 have not been so numerous as we should have liked. We have only been able to make quarterly observations at the seven chief stations—those on the lines Piel Gas Buoy—Calf of Man, and Calf of Man—Holyhead.

Mr. J. Johnstone, B.Sc., has, as usual, collected the samples.

The results obtained seem to fully bear out the conclusions we have come to in former reports.

The salinities at the various stations during 1910 were very similar to those found during 1909, and it is clear that the type of drift was the same during the two years. This was forecasted in last year's report from the results for February, 1910, which were to hand at the time of publication.

In the same report I discussed the possible connection between time of arrival and strength of the Gulf Stream Drift and the weather in these islands.* Events seem to have more or less justified the gloomy forebodings with regard to the summer of 1910 which I made in February of that year.

I do not, however, wish to insist too much upon this point, for the agreement of result and forecast may be merely accidental, but it is in any case interesting to see that in two successive years we find both a late and

*See also "Nature" LXXXIV., 44 (1910).

weak Gulf Stream Drift and wet and gloomy summer months.

It must also be mentioned that the gloomy summer of 1910 had not otherwise been foreseen—nay, rather the contrary, for as the result of 21 years' experience, meteorologists had become accustomed to expect one wet year to follow two dry ones.* According to this rule the year 1910 should have had a rainfall considerably below the average. Instead of this, however, the rainfall was a good deal in excess.

The maximum salinities at those of our stations (V, VI and VII) which are affected by the Gulf Stream Drift, occurred in May or June, 1910, and were slightly lower than in 1909. The water temperatures, however, were normal, and this can easily be explained. The unusually cold autumnal water from 1909 moving slowly northwards caused the water filling the north-eastern portion of the Irish Sea in the spring of 1910 to have just the normal temperature, in spite of the weaker Gulf Stream Drift, whereas for a somewhat similar reason the water in the spring of 1909 was warmer than usual since the Gulf Stream Drift of the preceding year had been of a more normal type.

As the salinities for October, 1910, appeared to indicate that the Gulf Stream Drift was gathering strength again, we collected samples at Stations V, VI and VII during December. There cannot be the slightest doubt, from the high salinities of these samples, that the Drift in 1911 has recovered what I regard as its normal value, and this is fully borne out by the results for February, 1911 (Station V, 34·27; Station VI, 34·36; Station VII, 34·07).

*See an article by Dr. H. R. Mill, on the rainfall of 1910, in "The Times" of Jan. 17, 1911.

It is very probable that the unusually mild winter we have experienced is connected with this return of the Gulf Stream Drift after the period of depression which it suffered during 1909 and 1910. The heavy rainfall during the last two months of 1910 may well be due to the same cause for the reasons discussed in last year's report and in *Nature*, LXXXIV, 44 (1910).

The renewed vigour of the Gulf Stream Drift also gives us good reason to expect a more genial summer, quite different from the dismal ones of 1909 and 1910.

The observations made at the different stations during 1910 are given in the following tables, where T°, Cl °/₀₀, S °/₀₀ and σ_t have the usual meanings. The seasonal variations of the salinities can be seen at a glance from the concluding table.

February 2, 1910

Stations I. to IV. Surface observations only.

Station.		Time.	T°.	Cl°/₀₀	S°/₀₀	σ_t
I.	54° N. ; 3° 30′ W.	8.40 a.m.	4·6	17·71	32·00	25·37
II.	54° N. ; 3° 47′ W.	9.40 a.m.	5·0	18·06	32·63	25·83
III.	54° N. ; 4° 4′ W.	10·40 a.m.	5·6	18·38	33·21	26·21
IV.	54° N. ; 4° 20° W.	11·40 a.m..	5·4	18·66	33·71	26·63

Station V. (1.25 p.m.), 53° 53′ N. ; 4° 46′ W. Depth of tation, 58·6 metres.

Depth (metres)	T°	Cl °/₀₀	S °/₀₀	σ_t
0	6·7	18·74	33·86	26·58
30	6·6	18·77	33·91	26·64
55	6·6	18·78	33·93	26·65

Station VI. (2.35 p.m.) 53° 43′ N.; 4° 44′ W. Depth of station, 75 metres.

Depth (metres)	T°	Cl °/oo	S °/oo	σ_t
0	7·13	18·78	33·93	26·58
30	7·2	—	—	—
70	7·2	18·79	33·95	26·59

Station VII. (3.35 p.m.), 53° 33′ N.; 4° 41′ W. Depth of Station, 58·6 metres.

Depth (metres)	T°	Cl °/oo	S °/oo	σ_t
0	6·8	18·67	33·73	26·47
30	6·75	—	—	—
55	6·75	18·67	33·73	26·47

May 2 to 3, 1910.

Stations I. to IV. Surface observations only.

	Station.	Date and Time.	T°	Cl°/oo	S°/oo	σ_t
I.	54° N.; 3° 30′ W.	2/5/10 (5.5 p.m.)	8·1	18·08	32·66	25·45
II.	54° N.; 3° 47′ W.	2/5/10 (6.5 p.m.)	7·7	18·43	33·30	26·00
III.	54° N.; 4° 4′ W.	2/5/10 (7.5 p.m.)	7·9	18·52	33·46	26·10
IV.	54° N.; 4° 20′ W.	2/5/10 (8.10 p.m.)	7·8	18·71	33·80	26·39

Station V., 3/5/10 (10.10 a.m.), 53° 53′ N.; 4° 46′ W. Depth of Station 69·6 metres.

Depth (metres)	T°	Cl °/oo	S °/oo	σ_t
0	7·7	18·86	34·07	26·61
30	7·55	18·85	34·05	26·61
68	7·55	18·88	34·11	26·66

Station VI., 3/5/10 (11.10 a.m.), 53° 43′ N.; 4° 44′ W. Depth of Station, 54·9 metres.

Depth (metres)	T°	Cl ‰	S ‰	σ_t
0	7·8	18·92	34·18	26·68
30	7·65	18·92	34·18	26·70
55	7·65	18·92	34·18	26·70

Station VII., 3/5/10 (12.15 p.m.), 53° 33′ N.; 4° 41′ W. Depth of station, 76·9 metres.

Depth (metres)	T°	Cl ‰	S ‰	σ_t
0	7·77	18·89	34·13	26·63
30	7·65	18·90	34·14	26·67
72	7·65	18·89	34·13	26·65

August 8 to 9, 1910.

Stations I to VII. Surface observations only.

Station.	Date and Time.	T°	Cl‰	S‰	σ_t
I. 54° N.; 3° 30′ W.	8/8/10 (3 p.m.)	16·1	18·16	32·79	24·07
II. 54° N.; 3° 47′ W.	8/8/10 (4 p.m.)	14·4	18·59	33·58	25·04
III. 54° N.; 4° 4′ W.	8/8/10 (5 p.m.)	14·0	18·71	33·80	25·28
IV. 54° N.; 4° 20′ W.	8/8/10 (5·55 p.m.)	13·4	18·80	33·96	25·53
V. 53° 53′ N.; 4° 46′ W.	9/8/10 (2.8 p.m.)	13·2	18.82	34·00	25·60
VI. 53° 43′ N.; 4° 44′ W.	9/8/10 (3.8 p.m.)	13·2	18·83	34·02	25·62
VII. 53° 33′ N.; 4° 41′ W.	9/8/10 (4.8 p.m.)	14·1	18·76	33·89	25·33

October 25, 1910.

Stations I. to IV. Surface observations only.

Station.	Time.	T°.	Cl‰	S‰	σ_t
I. 54° N.; 3° 30′ W.	8.35 a.m.	12·3	18·33	33·12	25·09
II. 54° N.; 3° 47′ W.	10.40 a.m.	12.5	18·54	33·49	25·34
III. 54° N.; 4° 4′ W.	11.35 a.m.	12·6	18·68	33·75	25·53
IV. 54° N.; 4° 20′ W.	12.30 p.m.	12·4	18·79	33·95	25·72

Station V., (2 p.m.), 53° 53′ N.; 4° 46′ W. Depth of station, 56·7 metres.

Depth (metres)	T°	Cl ‰	S ‰	σ_t
0	12·2	18·73	33·84	25·67
30	12·1	18·73	33·84	25·69
53	12·1	18·74	33·86	25·70

Station VI., (3 pm..), 53° 43′ N.; 4° 44′ W. Depth of station, 60·4 metres.

Depth* (metres)	T°	Cl ‰	S ‰	σ_t
0	12·1	18·84	34·04	25·84
30	12·5	18·83	34·02	25·75
55	12·5	18·83	34·02	25·75

Station VII., (4 p.m.), 53° 33′ N.; 4° 41′ W. Depth of station, 93·3 metres.

Depth* (metres)	T°	Cl ‰	S ‰	σ_t
0	11·9	18·84	34·04	25·88
30	12·9	18·83	34·02	25·68
85	12·9	18·82	34·00	25·66

December 20, 1910.

Stations V, VI., and VII. Surface observations only.

Station.	Time.	T°.	Cl‰	S‰	σ_t
V. 53° 53′ N.; 4° 46′W.	11.50 a.m.	9·8	19·06	34·43	26·58
VI. 53° 43′ N.; 4° 44′W.	10.50 a.m.	9·7	19·00	34·33	26·50
VII. 53° 33′ N.; 4° 41′W.	9.50 a.m.	9·3	18·91	34·16	26·44

* It will be noticed that the water at these two stations is in unstable equilibrium, as the heaviest water is at the top. We have occasionally noticed this before (see Lancashire Sea Fisheries Laboratory Report, No. 17, p. 61 (1909); also Trans. Biol. Soc. of Liverpool, Vol. XXIII, p. 163 (1909)).

The values for the surface salinities are collected in the following table:—

Station.	Feb. 2, 1910.	May 2-3, 1910.	Aug. 8-9, 1910.	Oct. 25, 1910.	Dec. 20, 1910.
I.	32·00	32·66	32·79	33·12	—
II.	32·63	33·30	33·58	33·49	—
III.	33·21	33·46	33·80	33·75	—
IV.	33·71	33·80	33·96	33·95	—
V.	33·86	34·07	34·00	33·84	34·43
VI.	33·93	34·18	34·02	34·04	34·33
VII.	33·73	34·13	33·89	34·04	34·16

THE PLANKTON ON THE WEST COAST OF SCOTLAND IN RELATION TO THAT OF THE IRISH SEA.

By W. A. Herdman, F.R.S., and Wm. Riddell, M.A.

In the "Intensive Study" of the plankton of the Irish Sea that has been carried on during the last four years, mainly from the Port Erin Biological Station as a centre, we have determined at least the main outlines of the characteristic seasonal variations in the leading groups of animals and plants composing the plankton in that district. Though individual years may be "early" or "late" or have other special features, as surely as the vernal equinox comes round so surely do we find the amount of the plankton in a "standard"* haul increasing in amount and becoming more markedly phyto-planktonic in character, until some time in April or early May the spring phyto-plankton maximum is reached, when the sea is found to be swarming with Diatoms and the hauls are much larger in volume than is usual throughout the remainder of the year (see Table, p. 174, column D = 100 c.c.). Then, after a few weeks, some time during May and June the phyto-plankton gradually dies away and is replaced by the zoo-plankton which is characteristic of the summer months (Table, col. E). Although, except in the case of occasional local or temporary swarms, this summer zoo-plankton is not nearly so abundant as the spring phyto-plankton, still it is equally characteristic and regular in its appearance.

* Made with a standard net, in a standard time and according to the standard manner.

In the late autumn (September or October) Diatoms again appear in profusion, constituting a second, autumnal, phyto-plankton maximum (Table, col. F) usually not so marked either in bulk or in duration as that in the spring. The autumnal phyto-plankton dies away in its turn, giving place to the scanty winter zoo-plankton—the minimum plankton of the year—which persists until the reappearance of the Diatoms in spring. This periodicity and the contrast between the phyto-plankton at one season and the zoo-plankton at another are most marked, as may be seen from the following table, which gives a summary of three characteristic hauls:—

	April Phyto-pl.	August Zoo-pl.	September Phyto-pl.
Chaetoceras	14,000,000	—	—
Rhizosolenia	—	—	16,000,000
Thalassiosira	2,000,000	—	—
Total Diatoms	16,790,000	—	16,528,000
Dinoflagellata	—	125	74,500
Sagitta	—	30	—
Podon	—	20	—
Total Copepoda	975	3,995	14,127
Fish Eggs	16	—	—

Here the April and the September gatherings are seen to be equally characterised by the abundance of Diatoms, which are totally absent in August, and September shows Dinoflagellata in addition, and August a pure zoo-plankton consisting mainly of Copepoda.

The seasonal variation in the bulk of the Irish Sea plankton is also seen well in curves or other graphic representations. The accompanying diagram (fig. 1) shows, for example, the curve for the catches of the whole plankton in the year 1908, as given by the large series of gatherings* extending over every month, taken

*See Trans. Biol. Soc. Liverpool, vol. xxiii, p. 244, 1909.

across Port Erin Bay. The high peaks in April and May, and then again, but to a less extent, in September and October, show the influence of the vernal and autumnal phyto-plankton maxima, and the effect would, of course, be still more marked in the curve showing the Diatoms alone. The autumn rise would in the curve for some years be greater than is shown in this particular case.

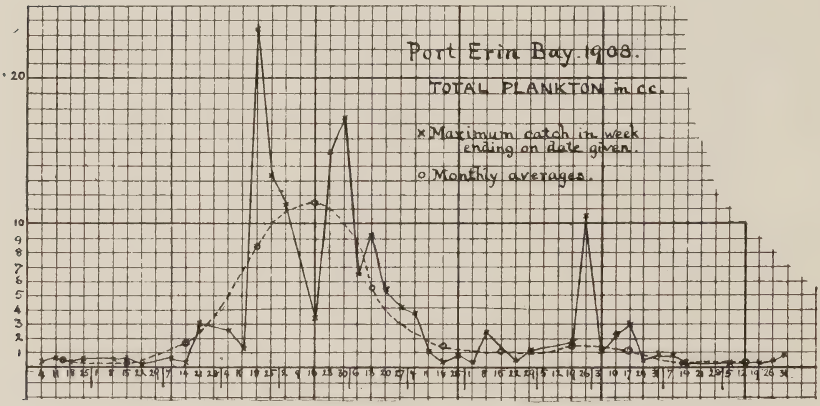


Fig. 1.

Taking the average of the last two years (see the solid black columns in fig. 2) in Port Erin Bay, we find that the monthly averages for the total plankton begin low in January and February, rise in March and still more in April, reach the maximum in May, drop rapidly through June, July and August to the summer minimum, rise a little in September and October to form the autumnal maximum, and fall again in November and December to the mid-winter minimum. In the previous year (1907), as will be seen from the other columns, the vernal maximum was a month earlier, and of great magnitude. The autumnal maximum is generally very much less than the vernal (although occasional hauls of some Diatom, such as *Rhizosolenia*, may be large), and is sometimes scarcely apparent. Both are caused by a very marked increase in the phyto-plankton, chiefly Diatoms (see lists in Table, p. 174); and the species which are the most abundant and characteristic at the two seasons are, for the most part, distinct.*

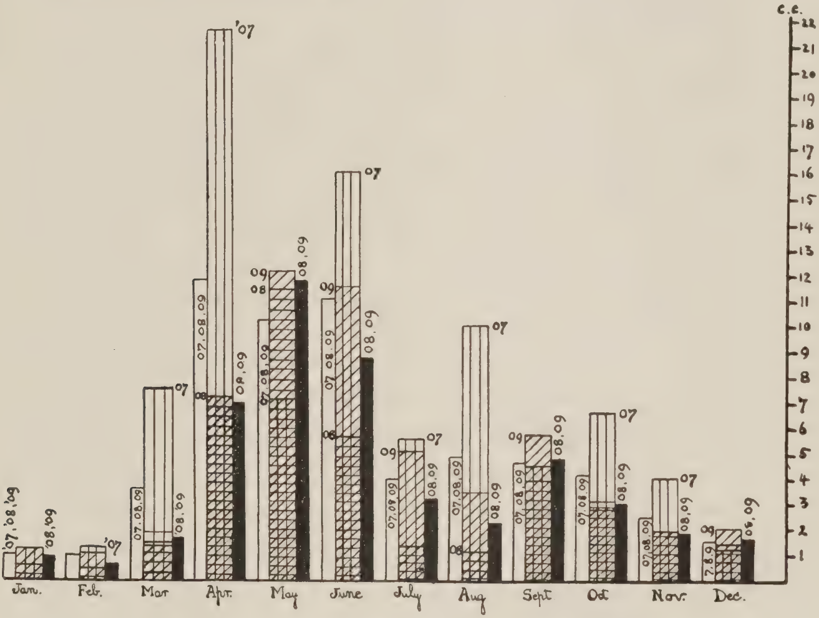


FIG. 2.

In summer, when the phyto-plankton is practically absent, the zoo-plankton reaches its maximum; but, in bulk, even at the maximum, the zoo-plankton (except on rare occasions when there is a swarm of some Copepod such as *Calanus*) is small compared with the spring gatherings of phyto-plankton (see columns D and E). A phyto-plankton gathering in the Irish Sea is

* See Trans. Biol. Soc. Liverpool, vol. xxii, p. 202, 1908.

practically only obtainable in spring or in late autumn; and if the gathering be a very large one (like D in our Table, p. 174: the September gathering shown in column F is unusually large for that time of year) it is almost certain to have been taken at the former period, say between the middle of March and the middle of May. We shall show further on in this paper that some of the above statements, descriptive of the planktonic yearly cycle in the Irish Sea, do not apply to the seas of the Hebrides off the West Coast of Scotland.

It is evident that in the conclusions we have arrived at for the Irish Sea, and which have also been demonstrated by other observers in other European seas (although it is still uncertain how far they extend to other oceans), there are various matters of great importance requiring explanation, for example:—

(1) What is the cause of the spring maximum?

(2) Even if some physical condition is found to be coincident with the great increase of Diatoms, we still require to know the origin of the first spring Diatoms that gave rise to the others. Were they present in the water during the winter in small numbers, were they in a resting condition on the bottom, or have they been carried in from the Atlantic or more Northern seas at or about the time of the increase?

(3) Why do the spring Diatoms disappear? Do they die off, sink to the bottom, or migrate out of our area?

(4) Do they remain on throughout the summer in deeper water, or in some localities, to any large extent?

(5) Why do Diatoms appear again in quantity in autumn, and why did those of them that differ from the spring species not develop in April if conditions were then favourable for such organisms?

(6) Do all the species of the summer and winter zoo-plankton remain all the year round in the Irish Sea, or do fresh invasions from outside occur each season?

Other questions might be stated, but the above will serve to show the fundamental nature of the problems—some of which involve the life-history and physiology of Diatoms throughout the year, and can evidently not be solved by an enquiry into the distribution alone.

Attempts have been made (see especially Jorgensen and Nordgaard, "Hydrogr. and Biolog. Investigations in Norweg. Fiords," Bergen, 1905) to answer similar questions in regard to other European seas; but we do not discuss these at present, since it is clear that the first thing required in connection with our local problems is to determine the relations of the Irish Sea plankton to that of the seas lying to the north and to the south and in the Atlantic outside Ireland and Scotland—both on the surface and in the depths. Such information will enable us at least to ascertain how far our seasonal changes in the plankton are due to migrations or invasions from outside. Now while it is possible to obtain the necessary information in regard to the sea-areas lying to the south of the Irish Sea, as the English Channel and the neighbouring part of the Atlantic between Ireland, Cornwall and France is being thoroughly investigated under the scheme of the International Council, no such data are obtainable in regard to the sea off the North end of Ireland and off the West Coast of Scotland. Practically nothing is known of the more minute and abundant constituents of the plankton in the sea between the North of Scotland and the North of Ireland. Beyond a paper in 1896 by Mr. George Murray, which we shall return to below, the Scottish Fishery Board do not seem to have published any investigations in regard to plankton in their Western seas; and it does not apparently form any part of their present scheme of work.

The publications of the Irish Fishery Department* do not give any information in regard to the minuter plankton (such as Diatoms) off the North Coast of Ireland and of the seas between Scotland and Ireland. Apparently only coarse-meshed nets have been used by the Irish investigators, and no Diatoms are entered in the published tables,† which deal with the zoo-plankton alone.

Finally, the map giving the stations in European seas at which plankton observations have been taken in recent years‡ shows a great unbridged gap extending from near Cape Wrath in the North of Scotland to Belfast Lough in Ireland. The whole of the seas round the Western Islands of Scotland, like the western coasts of England and Wales, have apparently been omitted from the Official International Scheme of investigation.

This state of affairs is, from the scientific point of view, most unfortunate, as, for a complete understanding of the plankton changes throughout the year in the Irish Sea, it is essential that we should have full

*There is a paper in "Fisheries, Ireland Sci. Invest." 1904, vi. (1906) by Gough, on Plankton collected at the Irish Light Stations, in 1904, but that record does not include any observations taken further North than Skulmartin Light Ship, which is South of Belfast Lough.

†Conseil Perm. Internat., Bull. Trimestriel, 1907-8, Copenhague, 1910.

‡Loc. cit., "Résumé Planktonique," Introduction, p. xii, 1910.

information, not merely as to the larger organisms of the zoo-plankton, but as to the planktonic conditions in general in both surface and deeper water along the North coast of Ireland and off the West of Scotland.

With the view of making a preliminary contribution to such knowledge as is required, one of us has spent a few weeks (July) during the last four summers (1907-1910, inclusive) in taking plankton hauls from the S.Y. "Ladybird" at various localities off the West Coast of Scotland; while the next few weeks (August and September) in each year were occupied in similar work further South in the Irish Sea. Even a superficial comparison of the two series of collections formed shows that the state of affairs in the Hebrides is very different from that in the Irish Sea, and is evidently worthy of more detailed examination and of careful consideration.*

The plankton hauls from the yacht were in all cases taken with the same nets and by the same method, so that the various gatherings are as nearly comparable as is possible. All the vertical hauls were made with the smaller "Nansen" closing-net (fig. 3) of No. 20 silk, and having a mouth of 35 cm. in diameter. Surface gatherings were sometimes taken at the same time with ordinary open surface tow-nets made of the same silk (No. 20) as the "Nansen" net and of approximately the same size of mouth. The Lucas sounding machine (fig. 4), fitted with 200 fathoms of pianoforte wire, was found to be most convenient and expeditious in taking these deep vertical hauls.

The temperature of the surface water of the sea in the Hebrides varied in this last summer, during the month, from 11·8° C. on July 11th, off Canna, to 13·1° C. on July 19th, off the North point of Eigg.

* A preliminary account of this work was laid before the Linnean Society on Nov. 3rd, 1910, and published in Linn. Soc. Journ., Zool., vol. xxxii, No. 208.

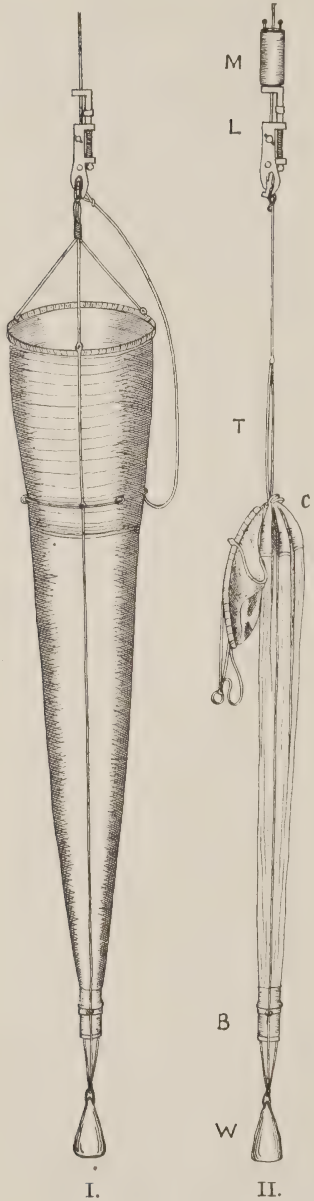


Fig. 3.—"Nansen" Closing Tow-net in action.

I. Open, as it descends and as it fishes.

II. Closed, as it is hauled in after fishing.

M. Messenger to effect closing;

L. Releasing apparatus;

T. Throttling noose;

C Canvas front to net;

B. Brass bucket containing the catch;

W. Weight.

During the same period the surface temperature off Port Erin in the Irish Sea ranged from 11·6° C. to 13·8° C.; so the temperature conditions are evidently very much the same in the two areas under consideration.

As one of the objects in view in this investigation was to obtain, for comparison with similar hauls in the

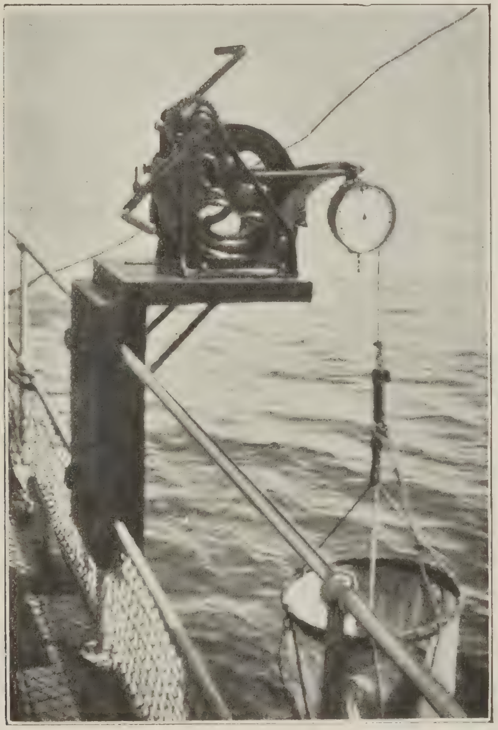


FIG. 4.—"Lucas" Sounding Machine as used with "Nansen" vertical closing net on S.Y. "Ladybird."

Irish Sea, as well as with one another, a series of samples of vertical hauls from the deeper parts of these western seas, localities were selected off the West of Scotland where the chart showed depths of over 50 fathoms, and in these areas a search was made for any deeper holes of over 100 fathoms. In addition to surface gatherings, and the Irish Sea series, we have now before us 33 successful vertical hauls in Scottish waters from depths of over 50 fathoms and 18 from over 100 fathoms. The deepest in the series are:—one of 133 fathoms between Croulin and Longa Islands in the Sound of Raasay, to the north of the great barrier formed by the large island of Skye, and one of 130 fathoms between Canna and Rum, to the South of Skye. The accompanying chart (fig. 5, p. 143), although on too small a scale to show details, will serve to give a general idea of the localities and of the distribution of land and water. It shows depths of over 50 fathoms shaded, and holes of over 100 fathoms are marked with a black outline. The twenty-five stations at which deep hauls were taken are marked by a small black circle enclosing a white cross.

The localities may conveniently be grouped in three series: (1) those outside and north of Cantyre, (2) those further south in the Clyde sea-area, and (3) those in the Irish Sea. The Northern Scottish series number 41, the Southern Scottish series 26, and those from the Irish Sea from depths of over 50 fathoms are 66.*

The hauls may be further classified as follows:—

I.—The term "Clyde Sea-Area" is used in the widest possible sense as including all localities inside a line from the Mull of Galloway to the Mull of Cantyre. The gatherings in that area can be grouped under the following localities:—

(1) A couple of hauls in the middle of the North Channel, off Portpatrick.

* We have also in our hands over 2,000 gatherings taken in these four years (1907-10) from shallower water in the Irish Sea, and these have been reported on fully in Trans. Biol. Soc., Liverpool, Vols, xxii-xxv, 1908-11.

FIG 5.

(2) Seven gatherings taken around Arran.

(3) Eight gatherings off Skate Island at the entrance to Loch Fyne.

(4) Six gatherings in Upper Loch Fyne.

II—The series North of Cantyre were mostly taken from between Oban and Skye. The gatherings can be arranged under the following localities:—

(5) Half-a-dozen from the Firth of Lorn and neighbourhood.

(6) Six from the Northern end of the Sound of Mull.

(7) Eight from around the Small Isles and the Sea of the Hebrides.

(8) Eight from Loch Nevis and Loch Hourn, Sound of Sleat.

(9) Ten from the Sound of Raasay, North of Skye.

III.—All the 66 deep hauls in the Irish Sea were from one locality, 12-16 miles N.N.W. of Port Erin, Isle of Man, from depths of 59 to 73 fathoms.

When we examine these groups of Scottish gatherings from the same places in different years, two conclusions become evident:—

(A) That localities, in some cases not very far apart, differ very considerably in the nature of their plankton at the same time of the year;

(B) That there is a constancy year after year in the nature of the plankton at some localities.

A few examples will make this clear:—

In regard to (A), in the Northern area (North of Oban) the hauls taken in Loch Hourn and Loch Nevis, off the Sound of Sleat, are on all occasions different in appearance from those taken off Ardmore in Mull, and from those taken off the Island of Canna; also those taken in the Lynn of Morven at one end of the Sound of Mull differ from those taken between Mull and Ardnamurchan at the opposite end. Again, in the Southern series (the Clyde sea-area) the hauls from off Skate Island, in the entrance to Loch Fyne, differ considerably in appearance from those taken further south in the Sound of Bute and the Firth of Clyde off Arran.

As examples of (B), the Loch Fyne vertical hauls are always characterised by the abundance of large Copepoda; the hauls off Canna and elsewhere in the sea of the Hebrides by the prevalence of Diatoms; those in the Firth of Lorn by a fine zoo-plankton, mixed with some phyto-plankton, and those in the Sound of Raasay, on the North of Skye, by a much coarser and more purely oceanic zoo-plankton.

Thus we have evidence that off the north-west coast of Scotland, at one time of year (July) in several successive seasons the plankton, as sampled by vertical hauls, was of different types (zoo- and phyto-plankton) in different localities, but preserved a constant character in each.

Let us now give the list of the Scottish localities in full, with some particulars as to the nature of the catch in each case:—

A.—SOUTH AND EAST OF CANTYRE. (CLYDE SEA-AREA.)

I. In North Channel.

(1) **Off Portpatrick,** 103 fm.; August 1st, 1909.—Chiefly zoo-plankton: *Calanus*, *Pseudocalanus*, and *Oithona*. Also *Rhizosolenia* spp., *Coscinodiscus radiatus*,

Ceratium spp., and a few neritic Diatoms, e.g., *Guinardia.* The species of *Chaetoceras* were mostly unrecognisable, but Diatoms on the whole are scarce. [Mainly oceanic in type.]

(2) **W.S.W. of Portpatrick,** 6 miles, 106 fm.; August 1st, 1909.—Much the same as above; zoo-plankton. [Oceanic in type.]

II. Round Island of Arran.

(1) **S. of Holy Island, Arran,** 54 fm.; July 31st, 1908.—Mostly zoo-plankton. *Rhizosolenia* in large numbers, also *Chaetoceras boreale, C. criophilum,* and *C. decipiens. Ceratium* fairly common. Also a few neritic forms, e.g., *Chaetoceras curvisetum, Guinardia,* and *Lauderia.* [Mainly oceanic in type.]

(2) **Off Cock of Arran,** 76 fm.; July 27th, 1907.—Zoo-plankton in fair quantity, chiefly *Calanus* and *Pseudocalanus.* Diatoms few; *Rhizosolenia semispina, Chaetoceras boreale, Coscinodiscus radiatus.* [Oceanic in type.]

(3) **Off Cock of Arran,** 80 fm.; July 30th, 1909.—Zoo-plankton in fair quantity. Diatoms numerous, both neritic and oceanic. *Chaetoceras curvisetum* is common, so also are *C. boreale* and *C. decipiens; Rhizosolenia* in fair numbers. *Ceratium* common. [? Oceanic in type.]

(4) **Loch Ranza, Arran;** July 27th, 1907.—A fair quantity of zoo-plankton. Diatoms mainly oceanic; *Rhizosolenia* common, also fair numbers of *Chaetoceras decipiens, C. densum,* and *C. boreale. Ceratium* fairly common. [Mainly oceanic in type.]

(5) **Loch Ranza, Arran,** surface; July 30th, 1908.—Very little zoo-plankton. Diatoms chiefly oceanic; *Rhizosolenia* commonest; also *Chaetoceras decipiens;*

fair number of neritic forms, *Chaetoceras curvisetum*, *Guinardia*, *Lauderia*, *Skeletonema*. *Ceratium* common. [? Oceanic in type, on the whole.]

(6) **Sound of Bute,** 95 fm.; July 30th, 1908.—Zoo-plankton in large quantity. Diatoms mainly oceanic; *Rhizosolenia* in large numbers, *Chaetoceras boreale* and *C. decipiens*. Neritic forms also present, e.g., *Chaetoceras curvisetum*, *Guinardia*, *Lauderia*, and *Skeletonema*. *Ceratium* common. [Mainly oceanic in type.]

(7) **Kilbrennan Sound,** 76-80 fm.; July 26th, 1907.—Much zoo-plankton, especially *Calanus*, *Pseudocalanus*, and *Oithona*. Diatoms oceanic; *Rhizosolenia* and *Chaetoceras boreale*. Many *Ceratium*. [Oceanic in type.]

III. Off Skate Island, Entrance to Loch Fyne.

(1) **Off Skate Island,** 104 fm.; July 18th, 1907.—Chiefly zoo-plankton; large numbers of *Calanus*. Diatoms few, both oceanic and neritic. *Ceratium* in fair numbers. [Oceanic in type.]

(2) **Off Skate Island,** surface; July 20th, 1908.—Zoo-plankton scarce. Diatoms chiefly oceanic; *Rhizosolenia* very common. *Ceratium* common. [Oceanic in type.]

(3) **Off Skate Island,** 95-105 fm.; July 20th, 1908.—Zoo-plankton common; large numbers of *Calanus*. Diatoms as in last. Many *Ceratium*. [Oceanic in type.]

(4) **Off Skate Island,** 100 fm.; July 28th, 1909.—Much zoo-plankton; *Calanus* common. Diatoms all oceanic. *Ceratium* scarce. [Oceanic in type.]

(5) **Off Skate Island,** 106 fm. (2 hauls); July 28th, 1909.—Great number of *Calanus*. Diatoms chiefly oceanic; *Rhizosolenia*, *Chaetoceras boreale*, *C. decipiens*. Fair numbers of *Ceratium*. [Oceanic in type.]

(6) **Off Skate Island,** 100 fm.; July 28th, 1909.—Much zoo-plankton, especially *Calanus* and *Pseudocalanus*. Diatoms almost all oceanic. No *Ceratium*. [Oceanic in type.]

(7) **Off E. Loch Tarbert,** 76 fm.; July 27th, 1907.—Large numbers of *Calanus*. Diatoms almost absent; a few *Rhizosolenia*. A fair number of *Ceratium*. [Oceanic in type.]

IV. Upper Loch Fyne.

(1) **Off Mt. Erins,** 83 fm.; July 28th, 1908.—A fair amount of zoo-plankton. Diatoms almost entirely oceanic. A fair number of *Ceratium*. [Oceanic in type.]

(2) **Off Newton,** 54-66 fm. (4 hauls); July 28th, 1908.—Much zoo-plankton. Diatoms chiefly oceanic. Fair number of *Ceratium*. [Oceanic in type.]

(3) **Upper Loch Fyne,** 70 fm.; July 29th, 1909.—Much zoo-plankton. Diatoms mainly oceanic. No *Ceratium*. [Oceanic in type.]

B.—NORTH OF CANTYRE.

V. Firth of Lorn.

(1) **Between Kerrera and Mull,** 80 fm.; July 21st, 1909.—More phyto- than zoo-plankton. Diatoms on the whole neritic, though many oceanic. [? Neritic in type.]

(2) **Off Bernera Island,** 110 fm.; July 21st, 1909.—More phyto- than zoo-plankton. Diatoms chiefly neritic; *Chaetoceras curvisetum* common; also *Ditylium*, *Guinardia*, *Lauderia*, and *Thalassiosira; Rhizosolenia* scarce. [Neritic in type.]

(3) **Off Bernera Island,** 110 fm.; July 22nd, 1910.—More phyto- than zoo-plankton. Neritic Diatoms in the majority; *Chaetoceras curvisetum*, *Thalassiosira*

gravida, and *T. nordenskiöldi* especially. Many *Chaetoceras decipiens* and a few *Rhizosolenia*. Few *Ceratium*. [Neritic in type.]

(4) **Firth of Lorn,** 108 fm.; July 22nd, 1910.—Mainly phyto-plankton. Diatoms chiefly neritic; especially *Chaetoceras curvisetum* and *Thalassiosira;* some *Rhizosolenia* and many *Chaetoceras decipiens*. Fair number of *Ceratium*. [Neritic in type.]

(5) **Firth of Lorn,** 116 fm.; July 22nd, 1910.—Same as above. [Neritic in type.]

VI. Iona Sound, W. of Mull

(1) **In Bull Hole,** at anchor; July 21st, 1907.—Phyto-plankton. Many *Achnanthes taeniata* and some *Asterionella*. Fair numbers of *Rhizosolenia*. [?Neritic in type.]

(2) **Iona Sound,** July 22nd, 1907.—Fair amount of zoo-plankton. Diatoms all *Achnanthes taeniata*. [Neritic in type.]

VII. North End of Sound of Mull.

(1) **Off Ardmore,** N. of Mull, 94 fm.; July 13th, 1909.—Chiefly phyto-plankton. Diatoms mostly neritic; *Chaetoceras curvisetum*, *Guinardia*, and *Lauderia*. Also a few oceanic forms. A fair number of *Ceratium*. [Mainly neritic in type.]

(2) **Off Ardmore,** 65 fm.; July 18th, 1910.—Chiefly phyto-plankton. Diatoms mainly neritic; large numbers of *Chaetoceras curvisetum* and *Thalassiosira*. Oceanic diatoms scarcer, e.g., *Rhizosolenia*. *Ceratium* not common. [Neritic in type.]

(3) **Off Ardmore,** 86 fm.; July 18th, 1910.—Same as above.

(4) **Off Ardmore,** 74 fm.; July 18th, 1910.—Same as above.

(5) **Loch Sunart,** 57 fm.; July 21st, 1910.—Chiefly phyto-plankton. Diatoms almost all neritic. *Ceratium* rare. [Neritic in type.]

(6) **In Tobermory Bay,** July 23rd, 1907.—Very little plankton. Diatoms few, oceanic [? type].

VIII. Round the Small Isles, and Hebridean Sea.

(1) **N.W. of Eigg,** 85 fm.; July 19th, 1910.—Mainly phyto-plankton. Diatoms chiefly neritic; very many *Chaetoceras curvisetum,* also *C. debile,* &c.; a fair number of *Chaetoceras decipiens* and a few *Rhizosolenia. Ceratium* not common. [Neritic in type.]

(2) **Loch Scresort, Rum,** surface; July 24th, 1907. A fair amount of zoo-plankton. Diatoms very few. [? type.]

(3) **Between Canna and Rum,** 130 fm.; July 13th, 1909.—A fair amount of zoo-plankton. Diatoms mainly neritic; *Chaetoceras curvisetum* commonest. A fair number of *Ceratium.* [Neritic in type.]

(4) **Between Canna and Rum,** 128 fm.; July 14th, 1910.—A fair amount of zoo-plankton. Diatoms mainly neritic; especially *Chaetoceras curvisetum, C. constrictum,* and *C. debile.* Few *Rhizosolenia;* a fair number of *Chaetoceras decipiens.* [Neritic in type.]

(5) **Off N. of Canna,** 105 fm.; July 14th, 1910.—Much the same as above. [Neritic in type.]

(6) **Off N. of Canna,** 80 fm.; July 14th, 1910.—Much as above; an even larger proportion of neritic Diatoms. [Neritic in type.]

(7) **Off Hyskeir Rocks,** surface; July 11th, 1910.—Chiefly phyto-plankton, but a fair amount of zoo-

plankton. Diatoms mainly neritic; very large numbers of *Chaetoceras curvisetum*, and many *C. debile* and *C. contortum*, &c.; also some *Guinardia*, *Lauderia*, and *Thalassiosira*. A few oceanic species, e.g., *Chaetoceras decipiens*. [Neritic in type.]

(8) **Vatersay Sound, Barra,** surface; July 12th, 1910.—A fair amount of zoo-plankton. Diatoms on the whole oceanic; *Chaetoceras decipiens*, *Rhizosolenia* spp., *Corethron;* a few neritic. [Oceanic in type.]

IX. Sound of Sleat.

(1 and 1a) **Loch Nevis,** 70 fm.; July 17th, 1908.—Two hauls, chiefly zoo-plankton. Diatoms few, a fair number neritic, but probably more oceanic. [? Mainly oceanic in type.]

(2) **Loch Nevis,** 75 fm.; July 14th, 1909.—Same as above, with greater number of *Schizopods*. [? Oceanic.]

(3) **Loch Hourn,** 45 fm.; July 17th, 1908.—More zoo- than phyto-plankton. Diatoms mostly neritic; *Biddulphia mobiliensis*, *Chaetoceras curvisetum*, *C. constrictum*, *Thalassiosira*. Few oceanic. [Mainly neritic in type.]

(4) **Loch Hourn,** 73 fm.; July 17th, 1908.—Much the same; possibly more zoo-plankton.

(5) **Loch Hourn,** 78 fm.; July 17th, 1908.—Much the same as above.

(6) **Loch Hourn** (Hensen net), 43 fm.; July 17th, 1908.—Much the same as above.

(7) **Loch Hourn,** 76 fm.; July 15th, 1909.—A much greater proportion of phyto-plankton. A large number of oceanic species. [Mainly neritic in type, but with a large admixture of oceanic.]

(8) **Loch Hourn,** near Beacon, 90 fm.; July 15th,

1909.—Diatoms fewer than above, majority probably oceanic. [? Oceanic in type.]

X. North of "Narrows of Skye."

(1) **Loch Duich,** 61 fm.; July 17th, 1909.—Mostly zoo-plankton. Diatoms mainly neritic. [? Neritic in type, with large mixture of oceanic.]

(2) **Loch-na-Beiste,** 6 fm.; July 17th, 1908.—A fair amount of zoo-plankton. A fair number of Diatoms; *Chaetoceras* spp. much broken and disorganised, but neritic species (*C. curvisetum*, &c.) seem to preponderate. Oceanic forms also present, but none in large numbers. [Neritic in type, but with a large proportion of oceanic.]

(3) **Loch Ainnert,** 20 fm.; July 18th, 1908.—Phyto-plankton small in amount. The species of *Chaetoceras* are largely unrecognisable. [? Neritic in type.]

(4) **Loch Ainnert,** 23 fm.; July 18th, 1908.—Much the same as above.

(5) **Loch Sligachan,** 12 fm.; July 18th, 1908.—A fair amount of zoo-plankton. *Chaetoceras* spp. again much broken up. [? Neritic in type.]

(6) **Off Longa Island,** 106 fm.; July 20th, 1908.—Practically all zoo-plankton. [? Oceanic in type.]

(7) **S. of Croulin Island,** 116 fm.; July 20th, 1908.—Same as above.

(8) **Between Croulin and Longa,** 133 fm.; July 16th, 1909.—Mostly zoo-plankton; more phyto-plankton than above, all oceanic. [Oceanic in type.]

(9) **Sound of Raasay,** 65 fm.; July 18th, 1908.—Practically all zoo-plankton. [Oceanic in type.]

(10) **Sound of Raasay,** 70 fm.; July 18th, 1908.—All zoo-plankton. [Oceanic in type.]

Remarks upon some of the Hauls.

All the vertical hauls taken in the deep hole, 95-106 fathoms, off Skate Island at the mouth of Loch Fyne consist of a coarse zoo-plankton (see fig. 6), characterised by a very great number (an average of 13,000 in five standard vertical hauls from about 100 fathoms) of the common Copepod, *Calanus helgolandicus*. These speci-

Fig. 6. Copepod Plankton, consisting wholly of *Calanus helgolandicus*.

Fig. 7. Diatom Plankton, consisting mainly of *Rhizosolenia semispina*.

mens of *Calanus* are large, and many of them are of a red colour when alive, and associated with them are generally a few *Euchaeta norvegica* and one or two specimens of the Schizopod *Nyctiphanes norvegicus*. There are also in these hauls a few smaller Copepoda (such as *Pseudocalanus elongatus*, *Acartia clausi*, and *Oithona similis*), some Copepod eggs and many nauplii, a few Sagitta, a few Echinoderm Plutei and Polychaet larvae, *Ceratium tripos*, and some Diatoms, chiefly species of *Rhizosolenia* and *Chaetoceras*. But the bulk of the catch is, in all cases, *Calanus helgolandicus*, and that gives it a characteristic appearance which can be seen as soon as the net comes up. We have, in all, eight vertical hauls taken during July in the years 1907, 1908 and 1909 (some of these are given in detail in the tables below), and also a surface gathering taken at the same locality on July 28, 1908. This surface gathering is, however, of an entirely different character from the vertical hauls. It is greenish in colour, and of fine flocculent appearance, and is in constitution a phyto-plankton (see fig. 7) almost entirely composed of oceanic Diatoms, chiefly species of *Rhizosolenia* (*R. semispina* 4½ millions, *R. shrubsolii* 1 million and *R. stolterfothi* 7 to 8 millions), and of *Chaetoceras* (about 5 millions). There are also about 30,000 Peridinians, and a very few small Copepoda, but the larger Copepods characteristic of the vertical hauls are entirely absent. It is evident that the larger Copepoda (*Calanus*) are in the deeper water and the Diatoms on the surface. A vertical haul from 83 fathoms, taken off Mount Erins, further up Loch Fyne, on that same date in July, 1908, shows the same type of gathering as the vertical hauls off Skate Island.

It is clear that the *Calanus* population extends in the deep water along the length of Loch Fyne, as hauls taken at various points in Upper Loch Fyne, both in 1908 and 1909, from depths of 54-70 fathoms show the same type of plankton as those taken off Skate Island. On the other hand, in working down the channel towards Bute, Arran and Kilbrennan Sound, we find that the gatherings are of a more varied nature. One off Sannox, Arran, on August 1st, 1910, from 70 fathoms, is a mixture of phyto- and zoo- plankton, and does not contain the large Calanoid Copepoda in any quantity. A haul taken off the Cock of Arran at the same season in the previous year, from a depth of 80 fathoms, had a fair number of large Copepoda, mixed however with Diatoms (*Rhizosolenia semispina*, *Chaetoceras boreale*, &c.), Peridinians and some smaller Copepoda. Another haul in the same spot in 1907 is of the same nature, with a still larger proportion of the smaller Copepoda (mainly *Pseudocalanus elongatus* and *Oithona similis*) and their nauplii. One in the Sound of Bute from a depth of 95 fathoms, on July 30th, 1908, had, along with the Calanoids and some smaller Copepoda, a very large number of Diatoms (chiefly species of *Rhizosolenia*), so much so as to be almost a phyto-plankton in appearance. Two hauls taken south of Holy Island, Arran, from 54 fathoms, in 1908, show also a mixed plankton, consisting of Diatoms and Peridinians along with the Copepoda. A haul from 80 fathoms in Kilbrennan Sound, on the West of Arran, on July 26th, 1907, consists of a coarse zoo-plankton, in which however there are many small Copepoda (*Pseudocalanus* and *Oithona*), and other animals (*Oikopleura* and larval forms), and a few Peridinians and Diatoms (*Rhizosolenia semispina*) mixed with the large Calanoid Copepods.

There are four vertical hauls taken, one in 1909 and three in 1910, off Ardmore, North of Mull, in the centre of the channel between Mull and Ardnamurchan (for full details see p. 149). These, and a vertical haul taken in the neighbouring Loch Sunart in 1910, are all alike in general character, consisting of a fine greenish phyto-plankton mixed with some Copepoda and nauplii and a few *Oikopleura*. The Diatoms are, in all the cases, mostly species of *Chaetoceras*. In 1910 there were also large numbers of *Nitzschia seriata,* of *Rhizosolenia stolterfothi,* and of *Thalassiosira gravida.*

Again, the six hauls taken in Loch Hourn (see p. 151), off the Sound of Sleat, a little further up the coast, and the three taken in the closely adjacent Loch Nevis, are all much alike in character but differ from those off Mull; consisting, as they do, of comparatively small catches not green in colour, chiefly made up of zoo-plankton and composed mainly of small Copepoda, some young *Nyctiphanes, Sagitta,* Polychaet larvae and many Tintinnidæ and Peridinians (especially in 1909), along with some Diatoms. The gatherings taken inside these neighbouring lochs on the mainland contrast markedly with hauls taken at the same time of year in the open sea further west, *e.g.,* off the Islands of Canna and Rum. A vertical haul from 85 fathoms on July 19th, 1910, between Eigg and Rum, and another on July 14th from 128 fathoms, between Canna and Rum, show well-marked green-coloured phyto-plankton; and other hauls off Canna on July 13th and 14th in the same year, from depths of 80, 105 and 130 fathoms, are also characteristic phyto-plankton gatherings composed chiefly of common species of *Chaetoceras.* The contrast between such a green Diatom haul taken in the sea of the Hebrides off Canna, in July, and a similarly captured haul at the entrance to Loch Fyne at the same time of year is most marked, the first being a typical fine phyto-plankton (such as fig. 8), and the latter a typical coarse zoo-plankton (fig. 6). As we have shown above, two such gatherings if obtained in the Irish Sea would be regarded as characteristic of two distinct seasons of the year, months apart. The difference between the Diatom hauls in the open sea and the fine zoo-plankton hauls in the deep fiords running into the mainland, such as Loch Nevis and Loch Hourn, is not so marked, but is still quite noticeable.

Hauls taken further North, on the other side of Skye, in the Sound of Raasay, off Longa Island and off the Croulins, from depths of 106, 116 and 133 fathoms, are all mainly zoo-planktonic, although not very large or characteristic in appearance. Some catches are coarser and some finer, some have more Calanoid Copepoda and

Fig. 8.—A phyto-plankton gathering from the sea round Canna, showing *Chaetoceras*.

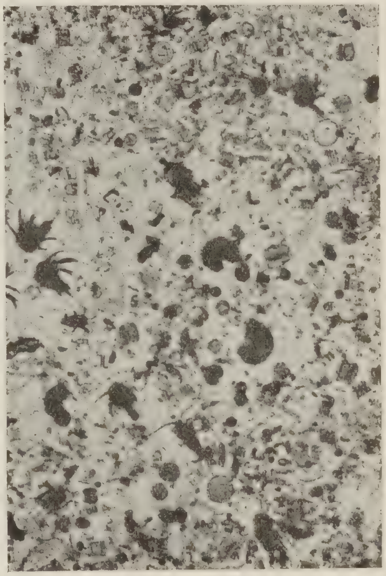


Fig. 9.—A mixed plankton, showing both Diatoms and Animals.

[From photo-micrographs by Mr. Edwin Thompson.]

Sagitta and Medusae, others have more of the smaller Copepoda (*Acartia*, *Pseudocalanus*, *Temora*, &c.) such as are shown in fig. 10; but there does not seem to be the constancy of character obtained in some other West Highland localities—except that all contain species of oceanic origin, a point we shall return to below. Further South again, in the Firth of Lorn and the Lynn of Morven, off Bernera Island, and between Kerrera and Mull, from depths of 80 to 116 fathoms, the gatherings, of which we have half-a-dozen for comparison, are composed of a grey or brownish fine material, which is

FIG. 10.—A Copepod zoo-plankton gathering showing *Acartia* and *Temora*.

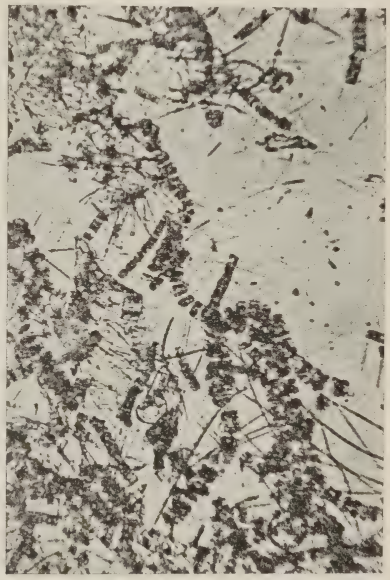


FIG. 11.—Sample, composed mainly of *Thalassiosira nordenskiöldii*.

[From photo-micrographs by Mr. Edwin Thompson.]

a mixed plankton (such as fig. 9 shows) neither characteristically phyto-planktonic nor zoo-planktonic, consisting, as it does, of small Copepoda, many Nauplii and Tintinnidæ, some *Sagitta* and *Oikopleura*, with a few *Ceratium*, more *Peridinium* and many Diatoms—the latter being mainly species of *Chaetoceras* (such as

C. curvisetum) with, occasionally, large numbers of *Thalassiosira gravida* and *T. nordenskiöldi*. Fig. 11 shows, under a higher magnification, part of an abundant gathering of the last-named Diatom.

Comparison of Hauls at the same Stations in Different Years.

We now give in the tables that follow a detailed analysis of the constitution of the catch from those stations* which are represented in more than one year, viz.:—Off Ardmore, Loch Hourn, off Canna and the other Small Isles, the Firth of Lorn, and off Skate Island.

Diluted samples of the catch were examined, one cubic centimetre at a time, in the "Rafter" counting cell,† and the method of estimating the number of individuals was precisely the same as that employed in reporting on the Irish Sea plankton during the last few years.

In the tables that follow the symbol x indicates mere presence, in very small numbers, to which we attach no great importance.

* With the exception of Loch Nevis, accidentally omitted from the tables, the results in that locality are very much the same as those for Loch Hourn.

† See Kofoid—Plankton Studies, in Bull. Illinois State Lab. Nat. Hist., Vol. V, 1897.

OFF ARDMORE.	1909.		1910.		Loch Sunart.
	July 13th, 94 fathoms.	July 18th, 65 fathoms.	July 18th, 86 fathoms.	July 18th, 74 fathoms.	July 21st, 57 fathoms.
Chaetoceras constrictum	21,700	—	—	—	1,098,500
„ curvisetum	1,870,250	14,930,600	18,571,450	14,857,150	36,000,000
„ debile	—	2,221,550	6,571,450	1,428,600	1,677,000
„ decipiens	8,700	217,000	2,071,440	714,275	750,000
„ spp.	225,700	10,286,500	20,357,150	20,714,300	4,571,000
Coscinodiscus radiatus	2,600	4,140	2,500	3,100	6,760
Ditylium brightwelli	—	1,230	625	—	—
Eucampia zodiacus	10,400	—	—	—	231,500
Guinardia flaccida	20,000	615	71,425	×	—
Lauderia borealis	26,000	477,430	357,145	285,700	289,000
Leptocylindrus danicus	—	130,200	—	—	—
Nitzschia seriata	—	2,777,800	1,642,850	714,275	1,070,000
Pleurosigma sp.	2,600	1,230	1,250	—	615
Rhizosolenia semispina	3,000	290,600	464,285	714,275	58,000
„ setigera	—	130,200	17,860	—	—
„ shrubsolii	×	238,700	190,475	142,860	58,000
„ stolterfothi	44,250	1,128,475	2,142,860	1,214,300	—
Skeletonema costatum	—	×	857,145	2,071,430	—
Thalassiosira gravida	45,150	2,647,600	1,428,575	1,214,300	752,500
„ nordenskioldi	—	607,640	571,430	214,300	694,500
Thalassiothrix nitzschoides	—	—	—	214,300	—
Dinophysis sp.	8,700	4,920	—	2,500	—

Peridinium	63,365	23,360	10,000	20,700	21,500
Ceratium furca	2,400	—	625	625	1,845
,, fusus	5,200	—	—	—	1,845
,, tripos	3,475	1,230	625	3,100	2,460
Tintinnidae	33,000	37,800	13,440	45,300	68,540
Medusae	46	33	13	8	16
Sagitta	1	25	25	32	1
Polychaet larvae	—	2	625	×	×
Plutei	—	310	3,600	2,500	—
Gasteropod larvae	—	3,075	7,500	10,700	615
Lamellibranch larvae	—	1,845	5,000	3,100	615
Schizopoda	—	2	6	2	1
Evadne nordmanni	870	615	—	—	—
Calanus helgolandicus	33	85	95	90	8
Pseudocalanus elongatus	9,000	2,450	5,100	3,100	2,460
Temora longicornis	—	615	935	—	—
Acartia clausi	—	720	—	935	615
Oithona similis	1,750	1,535	625	1,560	3,225
Copepoda juv.	870	—	1,875	1,875	615
Nauplii	11,700	22,450	25,625	29,060	7,375
Oikopleura	6,700	4,300	3,230	3,750	4,915

The three hauls in 1910 are, on the whole, very much alike, and indicate the degree of resemblance between hauls taken under similar conditions at practically the same time and place. In 1909 the numbers are smaller, but for the most part the same organisms are present, and in much the same proportions. Peridinians, *Evadne* and *Pseudocalanus* are more abundant.

The haul taken in Loch Sunart is clearly of the same nature as those off Ardmore.

LOCH HOURN.	1908.				1909.	
	July 17th, N. 73 fathoms.	July 17th, N. 45 fathoms.	July 17th, N. 78 fathoms. 3 hauls.	July 17th, H. 43 fathoms.	July 15th, 76 fathoms.	July 15th, Near Beacon, 90 fathoms.
Biddulphia mobiliensis	—	350	—	—	350	—
Chaetoceras constrictum	16,900	30,200	5,280	2,000	30,600	—
,, contortum	—	—	—	—	2,820	—
,, criophilum	—	—	—	—	2,100	—
,, curvisetum	71,850	34,000	24,000	2,670	51,000	22,170
,, densum	—	—	—	—	3,870	—
,, decipiens	7,750	8,000	835	—	36,760	17,600
,, spp.	66,170	75,600	43,100	6,260	66,170	32,000
Coscinodiscus radiatus	530	700	1,390	580	1,400]	700
Eucampia zodiacus	—	—	—	—	3,500	700
Guinardia flaccida	—	—	—	—	350	350
Nitzschia seriata	—	—	—	—	7,000	6,000
Pleurosigma sp.	265	175	50	—	350	350
Rhizosolenia semispina	—	700	—	115	3,870	1,760
,, shrubsolii	700	—	—	—	5,280	6,330
,, stolterfothi	—	—	—	—	2,100	3,500
Thalassiosira gravida	—	1,735	—	—	1,400	5,600

Thalassiothrix nitzschoides	—	—	—	—	3,170	2,460
Ceratium furca	—	350	280	—	700	530
,, fusus	—	350	—	—	3,170	1,760
,, tripos	700	1,040	280	—	350	350
Peridinium	12,670	8,300	10,300	5,450	64,000	42,550
Dinophysis	—	—	—	115	3,500	2,460
Tintinnidae..........................	9,500	10,000	7,500	2,100	35,000	21,800
Medusae	2	—	5	6	2	—
Plutei	—	350	—	—	—	—
Sagitta	—	1	3	2	4	4
Polychaet larvae	—	—	—	115	350	—
Nyctiphanes	—	—	1	—	—	1
Evadne nordmanni	—	—	—	115	—	—
Calanus helgolandicus	300	66	340	402	24	39
Pseudocalanus elongatus	1,940	350	1,715	145	2,000	890
Acartia clausi.........................	—	1,300	420	—	—	—
Oithona similis	1,400	700	750	800	700	1,400
Nauplii	6,500	8,200	5,740	4,800	11,260	6,000
Oikopleura	—	—	—	—	350	700

It is evident that more species, especially of Diatoms, were present in 1909 than in 1908 ; but the bulk of the catch in each case is very much the same. Peridinians, *Nitzschia*, *Rhizosolenia* and Tintinnidae are especially abundant in 1909.

SMALL ISLES.	Between Canna and Rum.		Canna.		Off N. of Eigg.
	July 13th, 1909, 130 fathoms.	July 14th, 1910, 128 fathoms.	July 14th, 1910, 105 fathoms.	July 14th, 1910, 80 fathoms.	July 19th, 1910, 85 fathoms.
Biddulphia mobiliensis	1,250	—	625	625	1,250
Chaetoceras constrictum	1,205,400	5,714,300	8,964,200	16,381,000	—
,, curvisetum	13,254,600	41,714,200	28,714,000	39,382,000	31,285,400
,, debile	—	5,285,700	4,535,700	—	3,392,800
,, decipiens	2,812,500	3,857,140	2,142,800	2,238,100	2,428,550
,, spp.	3,000,000	15,214,275	6,607,100	9,428,600	9,601,350
Corethron criophilum	—	—	—	1,250	625
Coscinodiscus concinnus	—	—	—	—	625
,, radiatus	5,000	4,690	8,440	3,125	9,685
Eucampia zodiacus	46,875	—	—	—	—
Guinardia flaccida	47,500	1,040	—	—	5,000
Lauderia borealis	21,875	23,960	5,625	3,125	128,125
Nitzschia seriata	3,125	357,140	500,000	571,430	1,678,650
Pleurosigma sp.	625	×	1,250	625	625
Rhizosolenia alata	—	—	—	1,875	—
,, semispina	12,500	142,750	125,000	129,375	110,000
,, setigera	—	—	—	—	1,250
,, shrubsolii	30,625	29,175	46,875	38,750	40,625
,, stolterfothi	101,250	17,715	31,250	23,750	119,375

Thalassiosira gravida	×	—	3,750	—	84,000
Dinophysis sp.	1,875	—	—	625	—
Peridinium spp.	112,500	18,750	13,750	33,750	20,000
Ceratium furca	35,000	—	940	625	—
„ fusus	26,875	1,040	2,530	—	—
„ tripos	18,750	5,210	12,200	7,500	1,250
Tintinnidae	41,250	22,920	18,750	23,750	28,125
Medusae	50	50	100	40	100
Sagitta	6	6	18	25	14
Polychaet larvae	625	×	1,250	×	—
Plutei	625	520	5,000	1,560	2,500
Gasteropod larvae	—	56,270	55,000	58,750	10,940
Lamellibranch larvae	—	—	—	—	625
Schizopoda	1	—	3	4	2
Calanus helgolandicus	350	500	750	400	110
Pseudocalanus elongatus	10,300	3,125	2,340	3,125	3,440
Temora longicornis	3,440	—	—	×	470
Acartia clausi	1,665	1,215	—	1,250	625
Oithona similis	5,940	4,430	3,125	3,125	3,125
Copepoda juv.	6,875	—	625	—	—
Nauplii	46,875	23,445	23,125	18,125	16,225
Balanus nauplii	—	—	625	1,250	—
Oikopleura	7,500	2,080	4,375	6,250	4,375

FIRTH OF LORN.	1909.	1910.		
	Kerrera and Mull, July 21st, 80 fathoms.	Off Bernera Island, July 22nd, ? 110 fathoms.	Firth of Lorn, July 22nd, 108 fathoms.	Firth of Lorn, July 22nd, 116 fathoms.
Biddulphia mobiliensis	1,560	—	—	—
Chaetoceras constrictum	—	137,500	—	—
,, curvisetum	—	1,208,400	7,457,000	4,333,250
,, debile	—	229,200	857,150	—
,, decipiens	—	1,045,900	2,571,400	1,045,150
,, spp.	3,135,935	1,900,000	8,114,300	4,300,000
Corethron criophilum	—	625	625	625
Coscinodiscus radiatus	7,815	8,125	14,375	11,250
Ditylium brightwelli	—	—	3,125	625
Eucampia zodiacus	—	85,625	33,125	21,250
Guinardia flaccida	5,470	3,125	14,375	10,000
Hyalodiscus sp.	—	1,250	625	625
Lauderia borealis	14,060	8,125	37,500	73,125
Nitzschia seriata	6,250	81,250	757,140	181,875
Pleurosigma sp.	9,375	4,375	1,250	1,875
Rhizosolenia semispina	15,625	4,375	21,250	36,250
,, setigera	—	1,250	8,750	3,125
,, shrubsolii	3,125	36,250	457,140	138,750
,, stolterfothi	45,310	27,500	21,875	81,875
Skeletonema costatum	—	15,625	16,250	30,000

Thalassiosira gravida	—	441,700	1,855,700	916,650
,, nordenskioldi	—	1,246,000	2,142,850	625,000
Thalassiothrix nitzschoides	6,250	—	—	—
Dinophysis sp.	4,685	625	—	1,250
Peridinium	14,685	31,250	88,125	74,375
Ceratium furca	1,560	310	1,250	—
,, fusus	3,125	×	6,250	1,560
,, tripos	—	625	3,125	×
Tintinnidae	39,000	25,000	75,625	58,125
Medusae	1	6	10	6
Plutei	×	1,250	625	625
Gasteropod larvae	×	625	6,250	1,875
Lamellibranch larvae	3,125	1,875	11,250	2,500
Sagitta	—	9	13	40
Polychaet larvae	3,125	1,250	—	1,560
Balanus nauplii	1,560	—	—	—
Calanus helgolandicus	5	400	250	300
Pseudocalanus elongatus	3,125	1,560	2,500	4,530
Temora longicornis	—	—	1,250	4,375
Acartia clausi	—	1,250	2,200	2,810
Oithona similis	1,560	625	—	—
Nauplii	7,030	15,000	26,250	23,125
Oikopleura	—	470	4,375	3,750

Rather fewer species are represented in 1909, but the prevalent organisms are much the same in the two years. *Calanus* and *Acartia* are more abundant in 1910, and also the Copepod Nauplii.

SKATE ISLAND.	1907	1908.			1909.	
	July 18th, 104 fathoms.	July 28th, Surface.	July 28th, 3 hauls, 95-105 fathoms.	July 28th, 100 fathoms.	July 28th, 2 hauls, 106 fathoms.	July 28th, 106 fathoms.
Chaetoceras boreale	—	178,570	107,150	4,585	597,140	595,140
,, decipiens	100	—	107,150	3,750	464,300	1,298,600
,, teres	100	285,700	—	—	—	—
,, subtile	300	—	—	—	—	—
,, spp.	—	4,571,400	3,071,400	—	1,161,700	—
Coscinodiscus concinnus	—	—	—	—	835	×
,, radiatus	—	—	1,250	—	4,170	3,130
Eucampia zodiacus	—	4,170	—	—	—	—
Guinardia flaccida	—	150,950	571,425	—	61,715	8,750
Lauderia borealis	—	16,680	16,250	—	×	—
Nitzschia seriata	—	—	—	—	—	3,050
Pleurosigma sp.	—	—	—	—	835	—
Rhizosolenia semispina	800	4,535,700	2,107,100	2,085	16,260	188,700
,, shrubsolii	—	928,570	1,392,850	415	9,590	85,610
,, stolterfothi	—	7,821,400	16,292,700	4,170	2,750,000	226,650
Ceratium furca	—	6,680	6,875	—	415	—
,, fusus	—	3,125	1,560	415	415	—
,, tripos	800	12,500	6,875	—	2,500	—

Peridinium	—	9,175	8,125	415	9,590	—
Dinophysis	—	1,250	×	—	—	—
Tintinnidae	—	3,340	20,000	415	12,925	12,500
Plutei	200	835	625	415	—	3,000
Sagitta	2	—	2	30	1	110
Polychaet larvae	300	—	—	210	415	—
Gasteropod larvae	—	—	1,875	—	—	—
Nyctiphanes	—	—	1	2	2	2
Podon intermedium	20	—	—	—	—	—
Evadne nordmanni	100	—	—	—	—	—
Copepoda juv.	8,000	1,250	—	—	—	—
Calanus helgolandicus	13,000	—	14,000	9,150	17,250	13,200
Pseudocalanus elongatus	3,460	—	4,220	6,570	2,920	103,190
Temora longicornis	20	—	—	—	—	—
Centropages typica	120	—	—	—	—	—
Acartia clausi	240	—	2,030	—	415	6,250
Oithona similis	1,880	—	940	—	625	3,130
Euchaeta norvegica	2	—	1	14	—	—
Nauplii	12,000	19,400	28,750	210	56,300	—
Oikopleura	30	—	—	—	—	—

With the exception of the surface gathering, these all show large hauls of *Calanus* and a few other Copepoda. The vertical hauls in 1908 show an unusual quantity of *Rhizosolenia*.

Designation of the Plankton.

If the hauls from these various localities are marked *P* or *Z* and *N* or *O* according as they are mainly Phyto-plankton or mainly Zoo-plankton, mainly Neritic or mainly Oceanic, the list comes out as follows :—

Date.	Depth in Fathoms.	No. of Hauls.	Zoo- or Phyto-plankton	Neritic or Oceanic	Remarks.
			Off Ardmore, Mull.		
July 13, '09	94	1	P.	N.	With some small Copepoda, Nauplii, etc.
,, 18, '10	65, 74 & 85	3	P.	N.	
			Loch Hourn.		
July 15, '09	76 and 90	2	Z.	? O.	With a certain admixture of phyto-plankton, which is not obvious until examined in detail.
,, 17, '08	73 and 78	4	Z.	? N.	
			Loch Nevis.		
July 14, '09	75	1	Z.	? O.	
,, 17, '08	70	2	Z.	? O.	
			Off Croulin and Longa.		
July 16, '09	133	1	Z.	O.	
,, 18, '08	65 and 70	2	Z.	? N.	
,, 20, '08	106 and 116	2	Z.	O.	
			Firth of Lorn.		
July 21, '09	80 and 110	2	P-Z.	N.	A larger proportion of Zoo-plankton present.
,, 22, '10	108, 110, 116	3	P-Z.	N.	
			Off Canna, Rum, etc.		
July 13, '09	130	1	P.	N.	With some Copepoda and a few other small animals.
,, 14, '10	80, 105, 128	3	P.	N.	
,, 19, '10	85	1	P.	N.	
			Skate Island.		
July 18, '07	104	1	Z.	O.	
,, 28, '08	83 and 95 to 105	4	Z.	O.	
,, 28, '09	100 to 106	4	Z.	O.	
			Upper Loch Fyne.		
July 28 & 29, 1908.	54 to 66	4	Z.	O.	
,, 29, '09	70	1	Z.	O.	

ARRAN, SOUND OF BUTE, ETC.

July 26, '07	76-80	1	Z. O.	
,, 27, '07	76	1	Z. O.	
,, 30, '08	95	1	Z. ?O. (mixed)	Diatoms also present.
,, 30, '09	80	1	Z. O.-N.	A few Diatoms.
,, 31, '08	54	2	Z. ?O. (mixed)	A few Diatoms and Peridinians.
Aug. 1, '10	70	1	P. —	Copepoda, etc., present also.

IRISH SEA—MID-CHANNEL.

Date.	Depth in Fathoms.	No. of Hauls.	Zoo- or Phyto-Plankton.	Remarks.
Apr. 7, '09	60	4	P.	Typical Spring Neritic Phyto-plankton.
,, 8, '09	60	5	P.	
Aug. 6, '09	59 to 60	5	Z.	
,, 7, '09	60 to 70	4	Z.	
,, 10, '09	60 to 73	4	Z. (mixed)	A few Diatoms present.
,, 17, '08	60 to 70	6	Z (mixed).	
,, 24, '07	60	10	Z. (mixed)	
Sept. 4, '07	60	12	Z.	
,, 12, '07	60	6	Z. (mixed)	Diatoms getting more numerous.
,, 12, '08	60 and 70	2	Z (mixed)	

Thus we have evidence that off the North-West coast of Scotland, at one time of year (July) in several successive seasons, the plankton, as sampled by vertical hauls, was of different types (zoo- or phyto-plankton and neritic or oceanic) in different localities, but preserved a fairly constant character in each.

Now in the Irish Sea, around the Isle of Man, as we have shown in the earlier parts of this paper, when the plankton of the whole year is considered, it is clear that neighbouring localities do not present widely different characters as they do in the Hebrides, and that a zoo-plankton and a phyto-plankton do not occur simultaneously a few miles apart.

In the Hebrides, as we have seen, very large phyto-plankton hauls may be taken year after year in July—when in the Irish Sea the hauls are for the most part comparatively small and are mainly composed of zoo-plankton. Mr. Andrew Scott, A.L.S., who has been associated with us for some years in studying the plankton of the Irish Sea, remarked when shown some of the phyto-plankton samples from Canna, Rum and Ardmore, "If I had not seen the locality and date on the bottles I should have placed them without doubt as Irish Sea gatherings taken in April." And the resemblance, it may be added, is not merely in general appearance, but extends to the microscopic composition. The gatherings from Ardmore, for example, contain abundance of *Chaetoceras* (several species), *Rhizosolenia shrubsolii* and *R. stolterfothi*, *Lauderia borealis*, *Thalassiosira gravida* and *T. nordenskioldi*—all of them Diatoms that are characteristic of an April gathering in the Irish Sea, off Port Erin. The abundance of the two species of *Thalassiosira* makes this and other July gatherings from the seas around Mull quite unlike a September Diatom haul in the Irish Sea, as the genus *Thalassiosira*, abundant in the North, is practically absent at the time of the autumnal maximum in the South.

In order to demonstrate still further the characters of these diverse planktons, and illustrate the comparison between the Scottish summer series and Irish Sea gatherings typical of different seasons, we give here in tabular form the quantitative details of:—

(A) a typical coarse zoo-plankton from off Skate Island at the entrance to Loch Fyne, July 18th.

(B) a zoo-plankton of somewhat different type (with fewer *Calanus*, but many more of the smaller Copepoda), from Kilbrennan Sound, July 26th.

(C) a mixed gathering, mainly phyto-plankton, from off Loch Ranza, Arran, July 27th.

These three somewhat diverse samples were obtained, it will be noticed, within a period of ten days, in July, from localities not ten miles apart.

We add, also, for comparison, the similar quantitative record of three characteristic gatherings made in the centre of the Irish Sea, off the West coast of the Isle of Man, near Port Erin, as follows:—

(D) a typical phyto-plankton, taken in April—a large haul (100 c.c.).

(E) a typical scanty zoo-plankton, from August (2·5 c.c.).

(F) a mixed gathering, mainly phyto-plankton, in September, when the autumnal Diatoms are present in quantities (11 c.c.).

Finally, we show in

(G) a typical phyto-plankton gathering from the Hebridean Sea, near Hyskeir, North of Mull,

for comparison with D and F.

It will be noticed, on comparing the Loch Ranza plankton with the Irish Sea hauls in April and September, that in species present, and their abundance, the Scottish July gathering is much more like the September than the April phyto-plankton; for example, in both July (C) and September (F) the most abundant form is *Rhizosolenia semispina*, a species rarely present and never abundant in April. But, as has been pointed out above, the phyto-plankton gatherings North of Mull (column G) show resemblances to the vernal rather than to the autumnal phyto-plankton of the Irish Sea, although to some extent combining their characters and differing from both.

Several possibilities occur as an explanation of this curious difference between the summer planktons in the Hebridean and the Irish Sea, respectively.

	Clyde Sea Area.			Irish Sea.			Sea of Hebrides.
Locality	L. Fyne	Kil-brennan	L. Ranza	P. Erin	P. Erin	P. Erin	
Date	July 18	July 26	July 27	April 5	Aug. 21	Sept. 12	July 11
Depth in fathoms	104	76-80	0	20-10	20-0	0	
Catch in c.cm.	30	28	11	100	2·5	11	
	A	B	C	D	E	F	G
Asterionella bleakeleyi	—	—	—	15,000	—	1,200	—
Biddulphia mobiliensis	—	—	—	15,000	25	—	—
Chaetoceras contortum	—	—	—	14,000,000	—	—	16,143,200 (+other spp.)
,, debile	—	—	500	—	—	3,000	3,714,360
,, decipiens ...	100	—	4,500	50,000	—	8,000	761,920
,, teres	100	—	—	50,000	—	60,000	—
,, subtile	300	—	3,000	—	—	140,000	—
,, curvisetum	—	—	—	—	—	—	22,809,950
,, boreale	—	500	5,500	—	—	—	—
,, densum ...	—	—	1,000	—	—	—	—
Coscinodiscus concinnus..	—	—	—	15,000	—	2,500	—
,, radiatus ...	—	—	500	—	—	1,250	1,875
Ditylium brightwelli ...	—	—	—	—	—	2,500	—
Eucampia zodiacus	—	—	—	—	—	4,000	—
Melosira borreri	—	—	—	—	—	5,000	—
Rhizosolenia alata	—	—	—	—	—	150,000	—
,, semispina	800	15,500	1,735,000	—	—	16,000,000	137,500
,, setigera ...	—	—	—	—	—	2,500	—
,, shrubsolii	—	—	4,000	—	—	20,000	25,310
,, stolterfothi	—	—	15,000	—	—	30,000	1,875
Thalassiosira gravida ...	—	—	—	90,000	—	—	23,125
,, nordenskioldi	—	—	—	2,000,000	—	—	—
Lauderia borealis	—	—	—	600,000	—	120,000	5,625
Leptocylindrus danicus	—	—	500	—	—	—	—
,, sp.	—	—	—	—	—	50,000	—
Pleurosigma sp.	—	—	500	—	—	—	—
Trochiscia sp.	—	—	1,000	—	—	—	—
Ceratium furca	—	—	—	—	—	7,500	625
,, fusus	—	—	500	—	25	17,000	—
,, tripos............	800	6,000	2,500	—	100	50,000	4,685
Peridinium sp.	—	2,500	300	—	50	—	27,810
Medusoid gonophores ...	1	—	150	—	—	7	—
Plutei of Echinoderms	200	500	1,250	—	—	—	625
Sagitta bipunctata	2	15	—	—	30	—	4
Larval Polychaeta.........	100	—	—	—	—	—	—
"Mitraria"	200	1,000	1,500	—	—	—	—
Crab zoea	20	—	—	6	—	—	—
Podon intermedium	20	100	—	—	20	—	—
Evadne nordmanni	100	1,600	1,250	—	—	—	—
Calanus helgolandicus ...	13,000	4,600	50	—	10	11	180
Pseudocalanus elongatus	3,460	48,700	150	250	300	60	1,400
Temora longicornis	20	200	—	225	65	—	—
Centropages hamatus ...	—	500	100	—	5	20	—
,, typica	120	—	—	—	—	—	—
Acartia clausi	240	1,000	200	300	110	900	1,460
Oithona similis	1,880	11,000	1,250	200	1,000	250	4,060
Paracalanus parvus	—	—	—	—	—	80	—
Copepod nauplii	12,000	18,500	45,000	—	2,000	9,000	19,375
,, Juv.	8,000	48,500	15,000	—	500	3,800	—
Gasteropod larvae	—	500	500	—	25	—	49,060
Lamellibranch larvae ...	—	500	600	—	50	—	—
Oikopleura sp.	30	1,000	600	1,500	500	10	625

It may be (1) that the great vernal maximum which dies away in May and June in the Irish Sea passes off more slowly further North, and is still found lingering on in some parts of the Hebrides, until the end of July, or possibly even longer. Or it may be (2) that in some of these deep northern channels the Diatoms that elsewhere constitute our vernal maximum remain on in comparative abundance throughout the greater part of the year. Still a third possible explanation is (3) that the Diatoms constituting these July phyto-plankton gatherings may have invaded the Hebridean seas from the North Atlantic at some period subsequent to the vernal maximum. Personally we are inclined to regard the first of these three suggestions as the most likely to be the correct explanation of the facts we have described, but we do not consider that it can yet be regarded as established by the observations before us. It is obvious that such a matter can only be determined by frequent periodic observations carried on throughout the year by means of vertical hauls at fixed localities. Such series of detailed observations have still to be made in the Scottish seas. Mr. George Murray, in 1896, took some series of horizontal tow-net gatherings at various localities round the coast of Scotland for the Scottish Fishery Board, and he published a brief report* the following year on his results. His observations were made in March, July, August and December, and were widespread, including several of the localities we have sampled; but they seem to deal mainly, if not wholly, with the surface of the sea, and in any case do not include vertical hauls in deep water. Murray does not give a detailed analysis of his catches, and unfortunately does not deal with the zoo-plankton; still it is interesting to

*S.F.B. Report for 1896, Vol. XV, part iii, p. 212.

note that his results, so far as they go, are not inconsistent with the observations recorded above. He found that in Loch Nevis and Loch Hourn the commonest Diatoms were *Chaetoceras decipiens* and *Rhizosolenia shrubsolii*, indicating some oceanic plankton; while elsewhere in that northern area the commonest species is the neritic *Chaetoceras curvisetum*—which agrees with our results for these localities.

Murray states that after the vernal maximum the Diatoms diminish in the Scottish waters, but do not disappear, and are to be found throughout the summer in local banks. *Skeletonema costatum* he notes as the most abundant and characteristic form on the surface generally in April, and in Loch Etive in August (this we only met with occasionally in our July hauls). The table he gives shows that there were fewer species of Diatoms in Loch Nevis and Loch Hourn than in the sea between Rum and Ardnamurchan—there being 28 in the latter column and only 7 in that for Loch Nevis.

So far, this comparison agrees with the abundant phyto-plankton gatherings we obtained off Rum and Canna, &c., and the comparatively small catches of zoo-plankton in the lochs on the mainland; but our hauls, being vertical from the bottom at great depths, probably sampled a much larger body of phyto-plankton, and included some species that did not appear at the surface.

In the "Fauna, Flora and Geology of the Clyde Area," published for the meeting of the British Association at Glasgow in 1901, Messrs. G. Murray and F. H. Blackman give a short (two pages) account of the phyto-plankton, which is in the main a summary of the above-mentioned report to the Fishery Board. They refer to the seasonal changes and the regular alternations of Diatoms and Peridiniæ. The Diatom maximum is described as being in the "early months of the year," and as diminishing at the end of March and beginning of April, which is certainly earlier than in the Irish Sea. The Peridiniæ are said to reach their maximum about August, and linger on until December. The predominant Diatom in the Clyde sea-area in spring is *Skeletonema costatum*, a species which has not as yet occurred in our gatherings in the Irish Sea. Even in summer, however, when Diatoms are practically absent at Port Erin, it is evident that in the Clyde sea-area "the Diatoms, though much less in total amount than in the earlier months, show a considerable increase in the number of forms."

Sir John Murray must have made many observations on the plankton of some parts of the West of Scotland, during his work from the yacht "Medusa"; but we understand that the results have not been published.

It may be added that Professor P. T. Cleve gave a short account, in the Scottish Fishery Board's Report for 1896, p. 297, of the phyto-plankton of the "Research" collections made in the Shetlands, and showed that the stations on the western side were rich in Diatoms (styli-plankton), while the hauls taken to the east of the islands were much poorer in Diatoms, but showed Dinoflagellates (tripos-plankton)—this again showing a difference between not very distant localities at the same time of year, due, according to Cleve, to the western stations being supplied by warmer Atlantic ("Gulf Stream Drift") water characterised by species of *Rhizosolenia*.

Oceanic and Neritic Plankton.

Let us examine now the evidence that our observations afford as to the so-called oceanic or neritic nature of the plankton in the several localities, and the bearing, if any, of such conclusions as to the origin of the organisms upon the hydrography of the area under consideration.

It is not clear that all recent writers have used the terms "oceanic" and "neritic" in quite the same sense, so it is necessary to state exactly the meanings which we shall attach to the words. Our definition, which agrees in essentials with Haeckel's original statement ("Plankton-Studien, 1890") would be as follows:—

"Oceanic" species are such as are characteristic of the open sea, although they may occasionally or periodically be carried inshore and become mixed in varying proportion with the coastal plankton. They have no fixed or resting bottom-stages in their life-history, and are therefore holoplanktonic.

"Neritic" species have their origin and their home in coastal waters, and although they may spread to some extent out to sea, they cannot live and reproduce there indefinitely, and consequently are not found normally in the open ocean. Many of them have fixed or resting bottom-stages in their life-history, and so belong to the meroplankton; but some neritic forms are holoplanktonic, being permanently free.

It is evident, then, that particular samples of plankton may be some of them oceanic and some neritic, while others will contain both oceanic and neritic species; but unless a considerable proportion of species from another source is present, conclusions ought not to be drawn as to the mixing of waters of diverse origin—far-reaching hydrographic conclusions ought not to be based upon the presence of a few individuals of supposed oceanic species in a neritic gathering.

It is difficult, in the first place, to feel certain as to which are oceanic and which are neritic species. Previous writers who have published lists, such as Cleve, Gough and Gran, are not always in agreement, and even when they are it seems in some cases an agreement due to there being few recorded occurrences rather than to a full knowledge of the distribution of the species. There is some danger of deceptive reasoning if species are classed, say, as oceanic on a comparatively small number of records, and if thereafter the occurrence of such species in any localities is used as an indication of the oceanic origin of the water. It is improbable that all planktonic species are either oceanic or neritic. It may well be that some species are intermediate in character and habitat, overlapping and intermingling with both, and liable to be placed sometimes in the one category and sometimes in the other. Then again, there may be some species which are cosmopolitan, or "Panthalassic," as we should prefer to call it, occurring both in the open oceans and also in the shallower coastal waters of some parts of the world.

The suggestion has been made* that amongst Diatoms the power of forming "resting-spores" ("Dauersporen" or "Dauerzellen") might properly be regarded as diagnostic of neritic species; but although it is natural to suppose that neritic species would be the first to develop such a dormant phase, it must not be assumed without proof that resting-spore formation cannot take place in any oceanic species, and therefore

* Hjort and Gran, Norwegian Marine Investigations, 1895-97, Bergens Museum, 1899.

it is scarcely justifiable to class a little-known species as neritic simply because it is found to produce a resting-spore.

Furthermore, even when dealing with species in regard to the oceanic nature of which there can be no reasonable doubt, it would be unwise to base hydrographic theories upon the occurrence of a few individuals upon one or a small number of occasions in perhaps a single locality. There are so many accidents by which small floating objects in the sea may be conveyed from place to place, even for considerable distances. Storms, prevalent or exceptional winds, high tides, unusual conjunctions of wind and tide, to say nothing of ships and other human agencies, may all on occasions play their part in helping to convey oceanic organisms (even one Diatom may suffice if it lives for a time and reproduces) into a neritic area where their presence must not be taken as being necessarily an indication of flooding with oceanic water.

It is for these reasons that we hesitate to put forward in any dogmatic spirit the hydrographic conclusions to which a consideration of the supposed oceanic and neritic organisms found in our West Coast and Hebridean plankton catches would seem to point. If, then, we now proceed to classify the species into the two categories, and show how they may possibly in their distribution afford an indication of the course taken by marine currents, it must be considered that we are putting forward suggestions which may be tested by future work rather than laying down conclusions which we regard as established.

It may be useful if we arrange the commoner species of the West Coast plankton in what would be regarded by most planktologists as their probable positions in the neritic and oceanic series; but it will be noticed that we have not hesitated to query a number of these determinations.

Oceanic.	Neritic.
	Achnanthes taeniata.
	Asterionella bleakleyi (?), *A. japonica.*
Bacteriastrum delicatulum, B. elongatum.	*Bacteriastrum varians.*
	Bellerochea malleus.
Biddulphia sinensis.	*Biddulphia aurita, B. mobiliensis.*
	Cerataulina bergoni.
Chaetoceras boreale, C. convolutum, C. criophilum, C. decipiens (?), *C. densum.*	*Chaetoceras anastomosans, C. constrictum, C. contortum, C. curvisetum, C. debile, C. didymum, C. diadema, C. diversum, C. furcellatum, C. laciniosum, C. lorenzianum, C. sociale, C. subtile, C. teres.*
Climacodium biconcavum.	
Corethron criophilum.	
Coscinodiscus radiatus (?)	*Coscinodiscus concinnus, C. grani.*
	Coscinosira polychorda.
	Ditylium brightwelli (?)
	Eucampia zodiacus.
	Guinardia flaccida (?)
	Hyalodiscus sp.
	Lauderia borealis.
	Leptocylindrus danicus.
	Melosira borreri.
	Nitzschia seriata (?)
	Pleurosigma sp.
Rhizosolenia alata, R. semispina.	*Rhizosolenia setigera, R. shrubsolii* (?), *R. stolterfothi* (?).
	Skeletonema costatum.
	Streptotheca tamesis.
Thalassiosira subtilis.	*Thalassiosira gravida, T. nordenskioldi.*
	Thalassiothrix nitzschoides.
Dinophysis sp.	
Peridinium spp.	
Ceratium furca, C. fusus, C. tripos.	*Prorocentrum micans.*
Dictyocha fibula.	*Hexasterias problematica.*
	Trochiscia.
Acanthometron sp.	*Tintinnopsis* sp.
	Noctiluca miliaris.
Sagitta bipunctata.	*Autolytus prolifer.*
Tomopteris catharina.	
Cupulita sarsi.	
Pleurobrachia pileus	

Oceanic.	Neritic.
Acartia clausi (?)	*Alteutha depressa.*
Anomalocera pattersoni	
Calanus helgolandicus.	
Candacia armata.	
Centropages typicus (?)	*Centropages hamatus* (?)
Clytemnestra rostrata.	
Corycaeus anglicus.	
Diaixis hibernica.	
Euchaeta norvegica.	*Isias clavipes.*
Metridia lucens.	
Microcalanus pusillus.	
Oithona similis.	
Oncaea subtilis. O. sp.	
Paracalanus parvus.	*Parapontella brevicornis.*
Pseudocalanus elongatus.	*Thalestris longimana, T. peltata, T. serratula.*
	Temora longicornis.
	Evadne nordmanni.
	Podon intermedium.
Oikopleura dioica.	

On the lines indicated in this list we have, in the previous parts of this paper, made use of the terms oceanic and neritic as applied to gatherings in which one or the other type of organism predominated; and if, on that basis, we now take into consideration all the evidence given in the preceding pages, we find that the West Coast of Scotland falls into three well-marked areas, not merely geographically, but also in the distribution of its summer plankton.

(1) The Clyde sea-area to the South of and inside Cantyre is characterised by zoo-plankton, and the species are, in the main, oceanic.

(2) The area around and to the North of Mull, extending from Cantyre to the southern coast of the Island of Skye, contains, in July, a well-marked phyto-plankton which is mainly neritic in character.

(3) To the North of Skye, again, a zoo-plankton appears which contains some oceanic species.

Whether the species regarded as characteristic in the first and third of these areas be really "oceanic" in the sense of having been carried in from the open ocean, or not, at any rate there is a real difference in the prevalent plankton which can be exemplified by the following selection of typical species:—

"Oceanic" species from the Clyde Sea Area.	"Neritic" species from the Seas round Mull.	"Oceanic" species from N. of Skye.
Chaetoceras boreale,	*Biddulphia mobiliensis.*	*Rhizosolenia semispina.*
C. criophilum.	*Chaetoceras constrictum.*	*Peridinium* sp.
Rhizosolenia alata,	*C. curvisetum*,	*Ceratium* spp.
R. semispina.	*C. debile*, *C. didymum.*	*Calanus helgolandicus.**
Peridinium sp.	*Eucampia zodiacus*	*Pseudocalanus elongatus.*
Ceratium spp.	*Lauderia borealis.*	*Oithona similis.*
*Calanus helgolandicus.**	*Leptocylindrus danicus.*	
Pseudocalanus elongatus.	*Thalassiosira gravida*,	
	T. nordenskioldi.	

We would point out that this is no case of distinguishing merely a region characterised by mero-planktonic species (which spend only a portion of their life in the plankton) from neighbouring seas containing holo-planktonic organisms (which live all their lives in the plankton). The species we have given in these three lists are all of them holo-planktonic,† equally unconnected with the sea-bottom at all stages of their existence; but there is general agreement that those in the central column inhabit coastal waters, and that the other two series are usually found in the open ocean or in water which there is reason to believe has recently come from the ocean. It is not necessary to suppose that all the individuals of the oceanic species have actually

* This is not affected by the fact that *Calanus* and some other Oceanic Copepoda live on all the year round in deep water close to land, such as at the entrance to Loch Fyne.

† We do not regard the fact that a Diatom's resting-spore may sink to the bottom and remain for a time in a dormant condition as sufficient to constitute that Diatom a mero-planktonic species.

been carried in by currents to where they are found. A few individuals may invade a neritic area either normally or accidentally (that is, as the result of unusual influences), and if they find suitable conditions, may reproduce actively and give a character to the plankton. This may be the case in localities like Loch Hourn and Loch Nevis, where there is a mixed plankton, appearing in some hauls to be rather more neritic, and in others more oceanic, in character. And it is only in this way, by supposing that the oceanic organisms having gained access to a suitable locality may there reproduce in quantity, that we can account for the presence of an oceanic element in an inshore loch or other locality closed in from the ocean by a sea containing neritic plankton.

If the attempt be now made to explain the plankton distribution on the West of Scotland in terms of hydrographic movements, it must be supposed that the Atlantic water gains access more freely in summer to the Clyde sea-area, and to the region North-East of Skye, than to the large area of the West Coast lying between. If an oceanic current reaches the Clyde sea-area, inside Cantyre, and another flows in round the North of Skye, while little or no such water invades the seas to the north and south of and around Mull, such a hydrographic distribution would go far to explain what we have observed in the distribution of the plankton.

Now Bassett* has shown that Atlantic water from the south flows slowly through the Irish Sea and out to the north, and Knudsen† has also stated that there is a constant flow of water up the Irish Sea to the West Coast of Scotland. If this current from the Irish Sea conveys

* Report Lancash. Sea-Fish. Lab., for 1909, p. 154.

† Publ. de Circonst., No. 39.

oceanic plankton to the Clyde sea-area, or if it encounters Atlantic water entering the North Channel between Ireland and Cantyre, and forces that stream with its contained oceanic organisms along the Ayrshire coast to Arran, Bute and Loch Fyne, that would sufficiently account for the distribution and character of the plankton in that region.

If there is no marked inflow of Atlantic water on the West Coast of Scotland, between Cantyre and Skye, in summer, as the prevalence of neritic plankton seems to indicate, it may be due to the Atlantic "Gulf Stream drift" flowing northwards, roughly parallel with the line of the outer Hebrides, to reach the North of Scotland and sweep round into the North Sea, thus enclosing an area within the Hebrides where the endogenetic, in the main neritic, plankton is left to develop in comparative freedom from invasion by oceanic or allogenetic organisms.

How far this state of affairs obtains, and how far the above suggested explanation will hold good for other times of the year, is still unknown. Further observations at other seasons, and extended to other localities, are most desirable in the interests of that fuller knowledge of the changes in the nature and in the abundance of the fundamental food-matters in our seas which is essential to an understanding of the movements of the shoals of migratory fishes.

REPORT ON MEASUREMENTS OF PLAICE MADE DURING THE YEAR 1910.

By Jas. Johnstone.

1. Introduction.

The measurements of plaice caught by the Officers of the Committee in the course of the routine trawling experiments have been continued on much the same lines as in the year 1909. For various reasons the number of fish dealt with is not so great as in 1909—altogether 35,000 plaice have been measured on board the vessels, and in the laboratories at Liverpool and Piel. The general objects of the investigation are to provide data for a study of the utility of trawl-mesh restrictions; for a study of the variation in the prevalent lengths of plaice on the various fishing grounds and at various seasons throughout the year; and indirectly for a study of migration paths and seasons. In last year's report I gave an outline of the preliminary results then apparent from the data, and it will not be necessary to do this again. It is expected that the Lancashire Fisheries Committee will continue this work and that it may be extended so as to include several fishing grounds lying, strictly speaking, outside their proper area. So far as the grounds sampled during the past year are concerned the scale of the experiments is probably sufficient—that is to say, the numbers of plaice measured are probably great enough to yield reliable estimates. The chief defect of the investigations of 1910 is that pointed out in last year's Report, that is, not nearly enough plaice are examined with regard to age, sexual condition, and weight. But this part of the work is very laborious, and with the resources at the present disposal of the Committee, the number of fish so examined cannot, probably, be exceeded.

Tables are given, as in last year's Report, and are constructed in the same manner. No comparisons are yet made between different years, so that the question of error has not been touched. But the data are given, just as they are collected, the only groupings being that of the inclusion of all fish caught on the same ground, during the same month, in the same column. Measurements are given in centimetres, the only satisfactory unit, as Professor Heincke has already insisted. Standard deviations and probable errors can then be easily ascertained.

From the beginning of these investigations I recognised that an error was inherent in the system of examining fish some time after capture—that of the *post-mortem* contraction of the animal. Fortunately the mean magnitude of this error can easily be ascertained, for all samples of plaice sent to me by Captain Wignall have been measured immediately (less than half an hour) after capture. On reaching the laboratory they are again measured, and the Table on p. 206 shows in parallel columns the results of these two series of measurements. Obviously the point involved is one of some practical importance in view of the possible imposition of restrictions on trawl fishing with respect to the lengths of fish permitted to be taken; and Captain Wignall's measurements form an important contribution to the solution of a question which might conceivably trouble the lawyers and magistrates who may have to deal in the future with size-limits of trawled plaice.

Whether or not one believes in the application of rigid statistical methods to such data as are here dealt with, it is necessary to make trial of them, and I give, in an appendix, a preliminary study of the application of some biometric methods to the treatment of fish measurements. It is probable that the mathematical treatment of the data will yield results of value. A catch of fish, even a catch of several hundreds of specimens, must not be regarded as giving anything more than a very rough idea of the nature of the "population" of which it is a sample; and certainly the figures taken from the theoretical catch deduced from the rough data will always be more probable ones.

It is quite certain that the methods of this investigation, combined with the study of the statistics of the local fisheries, would be of very great value for the study of regulations designed so as to lead to the most profitable exploitation of the fishing grounds. But the fishery statistics themselves are far too general to be of use. It is surely a most obvious necessity for successful fishery regulation that the monthly yield of each local fishing ground should be known, and known in such a way that one could stimate its limits of error: yet I do not know how such figures can be obtained.

	Luce Bay, 6 inch net.		King William Bank	Duddon Banks, 6 inch net, 1910.					
	October.		April.	Mar.	April.		May.		Oct.
	No.	No.	No.	No.	No.	%	No.	%	No.
11·5	3	Mature plaice in preceding catch.	—	—	—	—	1	0·54	—
12·5	1		—	1	—	—	1	0·54	1
13·5	3		—	—	5	1·25	2	1·09	1
14·5	11		—	—	22	5·51	3	1·64	4
15·5	40		—	1	27	6·77	6	3·28	2
16·5	119		—	2	40	10·02	7	3·82	13
17·5	109		—	5	36	9·02	12	6·55	11
18·5	90		—	10	53	13·28	12	6·55	29
19·5	119		1	6	42	10·52	9	4·92	35
20·5	142		—	11	31	7·77	10	5·46	22
21·5	119		—	12	21	5·26	5	2·73	8
22·5	120		—	7	15	3·76	6	3·28	5
23·5	75		1	4	14	3·51	10	5·46	3
24·5	75		—	9	18	4·51	9	4·92	2
25·5	53		—	5	18	4·51	24	13·10	1
26·5	59		2	4	20	5·01	11	6·01	2
27·5	40		1	2	11	2·76	16	8·74	—
28·5	45		1	3	6	1·50	13	7·10	—
29·5	47	—	—	1	7	1·75	6	3·28	1
30·5	48	1	—	2	4	1·00	9	4·92	—
31·5	50	4	1	1	2	0·50	4	2·18	1
32·5	50	6	—	—	1	0·25	2	1·09	—
33·5	56	15	4	—	3	0·75	1	0·54	—
34·5	45	20	—	—	1	0·25	3	1·64	—
35·5	48	39	3	—	—	—	1	0·54	—
36·5	31	24	4	—	1	0·25	—	—	—
37·5	28	26	—	—	—	—	—	—	—
38·5	25	25	2	—	—	—	—	—	—
39·5	20	20	1	—	—	—	—	—	—
40·5	12	12	—	—	—	—	—	—	—
41·5	10	10	1	—	—	—	—	—	—
42·5	8	8	1	—	—	—	—	—	—
43·5	9	9	2	—	—	—	—	—	—
44·5	12	12	—	—	1	0·25	—	—	—
45·5	2	2	—	—	—	—	—	—	—
46·5	8	8	—	—	—	—	—	—	—
47·5	3	3	1	—	—	—	—	—	—
48·5	4	4	1	—	—	—	—	—	—
49·5	6	6	2	—	—	—	—	—	—
50·5	1	1	—	—	—	—	—	—	—
51·5	1	1	—	—	—	—	—	—	—
52·5	—	—	—	—	—	—	—	—	—
53·5	1	1	—	—	—	—	—	—	—
54·5	1	1	—	—	—	—	—	—	—
55·5	—	—	—	—	—	—	—	—	—
56·5	1	1	—	—	—	—	—	—	—
Totals ...	1750	259	29	86	399	99·96	183	99·92	141

Barrow Channel—6 inch mesh—1910.

	March.		June.		November.	
	No.	%	No.	%	No.	%
12·5	—	—	—	—	—	—
13·5	—	—	—	—	—	—
14·5	—	—	6	0·37	1	0·68
15·5	11	3·79	15	0·94	10	6·84
16·5	61	21·03	40	2·51	19	13·01
17·5	96	33·11	89	5·59	32	21·92
18·5	59	20·34	177	11·10	16	10·96
19·5	38	13·10	203	12·75	14	9·59
20·5	18	6·21	315	19·77	19	13·01
21·5	2	0·69	260	16·32	8	5·48
22·5	2	0·69	239	15·00	11	7·53
23·5	2	0·69	130	8·16	6	4·11
24·5	—	—	62	3·89	2	1·37
25·5	1	0·34	31	1·95	3	2·05
26·5	—	—	9	0·56	3	2·05
27·5	—	—	8	0·50	2	1·37
28·5	—	—	4	0·25	—	—
29·5	—	—	2	0·13	—	—
30·5	—	—	2	0·13	—	—
31·5	—	—	—	—	—	—
32·5	—	—	—	—	—	—
33·5	—	—	1	0·06	—	—
34·5	—	—	—	—	—	—
35·5	—	—	—	—	—	—
36·5	—	—	—	—	—	—
37·5	—	—	—	—	—	—
38·5	—	—	—	—	—	—
39·8	—	—	—	—	—	—
40.5	—	—	—	—	—	—
45·5	—	—	—	—	—	—
Totals ...	290	99·99	1593	99·98	146	99·97

Blackpool Closed Ground, 6 inch net, 1910.

	July.	August.	September.
	No.	No.	No.
13·5	2	—	—
14·5	1	—	1
15·5	1	1	2
16·5	3	6	6
17·5	14	6	17
18·5	30	10	3
19·5	58	11	15
20·5	46	12	13
21·5	42	5	19
22·5	35	3	24
23·5	37	2	20
24·5	30	1	23
25·5	13	1	23
26·5	17	2	11
27·5	10	3	9
28·5	6	3	1
29·5	5	—	8
30·5	6	—	1
31·5	1	—	1
32·5	3	—	1
33·5	1	—	—
34·5	1	—	—
35·5	1	—	—
36·5	1	—	—
37·5	1	—	—
38·5	—	—	—
Totals	365	66	198

Near Nelson Buoy, 6-inch mesh, 1910.

	May		June.		July.		August.		September.		October.		November.
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
12·5	—	—	—	—	1	0·07	1	0·12	—	—	1	0·09	—
13·5	—	—	—	—	—	—	2	0·23	2	0·18	3	0·30	—
14·5	—	—	—	—	3	0·18	10	1·18	7	0·64	12	1·20	1
15·5	—	—	3	0·83	12	0·72	27	3·18	28	2·58	30	2·99	—
16·5	1	0·72	7	1·93	34	2·06	46	5·43	85	7·83	86	8·57	2
17·5	3	2·15	14	3·88	80	4·84	41	4·84	92	8·48	78	7·78	1
18·5	2	1·44	29	8·03	120	7·28	42	4·96	96	8·88	78	7·78	1
19·5	4	2·88	29	8·03	154	9·34	40	4·72	68	6·26	52	5·18	3
20·5	5	3·59	39	10·80	185	11·22	39	4·60	74	6·82	36	3·59	—
21·5	12	8·63	53	14·69	234	14·19	43	5·07	59	5·44	33	3·29	—
22·5	17	12·23	51	14·13	236	14·31	71	8.38	63	5·80	62	6·18	—
23·5	11	7·91	39	10·80	196	11·89	81	9·56	75	6·91	64	6·38	1
24·5	12	8·63	30	8·31	166	10·07	93	10·98	83	7·65	73	7·28	2
25·5	15	10·79	27	7·48	104	6·30	81	9·56	85	7·83	71	7·08	1
26·5	20	14·39	14	3·88	49	2·97	78	9·21	90	8·29	70	6·98	2
27·5	13	9·35	10	2·77	39	2·36	66	7·79	69	6·36	80	7·98	3
28·5	11	7·91	6	1·66	9	0·54	50	5·89	49	4·51	74	7·38	3
29·5	8	5·75	7	1·93	13	0·79	12	1·42	34	3·13	39	3·89	3
30·5	1	0·72	2	0·55	3	0·18	7	0·82	13	1·20	29	2·89	—
31·5	2	1·44	1	0·28	3	0·18	6	0·71	10	0.92	15	1·49	—
32·5	1	0·72	—	—	3	0·18	4	0·47	3	0·27	8	0·80	1
33·5	—	—	—	—	—	—	2	0·23	—	—	4	0·40	—
34·5	—	—	—	—	2	0·14	3	0·35	—	—	2	0·20	—
35·5	—	—	—	—	3	0·18	1	0·12	—	—	2	0·20	—
36·5	—	—	—	—	—	—	1	0·12	—	—	—	—	—
37·5	1	0·72	—	—	—	—	—	—	—	—	—	—	—
45·5	—	—	—	—	—	—	—	—	—	—	1	0·09	—
Totals	139	99·97	361	99·98	1649	99·99	847	99·94	1085	99·98	1003	99·99	24

Off Mersey Estuary, Shrimp Trawl ($\frac{1}{2}$ inch mesh) 1910.

	Feb.	Mar.	Apl.	Total Feb. to April.	May.	July.	Sept.	Nov.	Dec.
	No.	No.	No.	%	No.	No.	No.	No.	No.
3·5	1	—	—	0·04	—	—	—	—	—
4·5	32	2	4	1·56	—	—	—	—	16
5·5	152	12	147	13·07	—	—	2	—	112
6·5	91	47	252	16·39	6	—	5	2	163
7·5	53	139	185	15·84	12	1	14	4	66
8·5	27	226	57	13·03	15	2	6	5	26
9·5	38	168	50	10·76	29	7	1	2	22
10·5	22	91	37	6·30	20	25	2	8	5
11·5	17	49	26	3·87	8	35	6	1	5
12·5	19	38	19	3·19	—	32	4	1	—
13·5	21	33	12	2·78	1	26	1	2	2
14·5	19	41	16	3·19	—	3	2	3	2
15·5	7	36	20	2·65	1	3	6	3	1
16·5	2	32	22	2·35	—	2	4	4	—
17·5	1	29	12	1·76	—	2	4	4	—
18·5	2	16	4	0·92	1	2	3	4	—
19·5	1	9	7	0·71	—	—	3	1	—
20·5	—	10	3	0·54	1	—	—	—	—
21·5	—	5	1	0·25	—	—	2	1	—
22·5	—	4	1	0·20	—	—	—	1	—
23·5	—	2	—	0·08	—	—	—	1	—
24·5	—	9	—	0·38	1	—	—	3	—
25·5	—	—	—	—	—	—	1	3	—
26·5	—	—	—	—	—	—	1	1	—
27·5	—	—	1	0·04	—	—	—	4	—
28·5	—	—	—	—	—	—	—	2	—
29·5	—	—	—	—	—	—	—	1	—
30·5	—	—	—	—	—	—	—	1	—
31·5	—	—	—	—	—	—	—	2	—
32·5	—	—	—	—	—	—	—	2	—
33·5	—	—	—	—	—	—	—	—	—
Totals	505	998	876	99·90	95	140	67	66	420

Off Mersey Estuary, 4 inch and 7 inch nets, 1910.

	4 inch net.		Horse Channel, 7 inch net.						Rock Channel, 7 net.	
	July.		September.		October.		November.		November.	
	No.	%	No.	%	No.	%	No.	%	No.	%
12·5	6	0·55	—	—	—	—	—	—	—	—
13·5	7	0·64	—	—	—	—	—	—	—	—
14·5	22	2·01	—	—	—	—	—	—	—	—
15·5	20	1·83	2	0·26	2	0·18	—	—	2	—
16·5	48	4·38	8	1·06	17	1·58	—	—	17	—
17·5	76	6·94	26	3·44	52	4·84	2	0·81	55	—
18·5	138	12·61	52	6·88	144	13·42	6	2·46	121	—
19·5	121	11·06	109	14·44	180	16·78	3	1·23	154	—
20·5	107	9·78	96	12·72	85	7·92	2	0·81	88	—
21·5	139	12·71	93	12·30	115	10·72	7	2·87	82	—
22·5	120	10·96	63	8·34	68	6·32	4	1·64	65	—
23·5	98	8·95	53	7·02	57	5·31	7	2·87	69	—
24·5	84	7·68	58	7·67	57	5·31	12	4·91	24	—
25·5	39	3·56	39	5·16	49	4·56	8	3·28	17	—
26·5	30	2·74	37	4·90	36	3·35	13	5·32	13	—
27·5	14	1·28	35	4·63	58	5·40	26	10·65	5	—
28·5	4	0·36	25	3·31	43	4·01	26	10·65	2	—
29·5	7	0·64	28	3·71	41	3·82	26	10·65	3	—
30·5	1	0·09	14	1·85	21	1·95	26	10·65	—	—
31·5	2	0·18	6	0·79	26	2·42	19	7·79	1	—
32·5	2	0·18	6	0·79	9	0·84	26	10·65	—	—
33·5	3	0·18	2	0·26	6	0·56	11	4·51	—	—
34·5	2	0·18	2	0·26	3	0·28	7	2·87	—	—
35·5	—	—	—	—	2	0·18	4	1·64	—	—
36·5	1	0·09	1	0·13	1	0·09	3	1·63	—	—
37·5	1	0·09	—	—	—	—	2	0·81	—	—
38.5	1	0·09	—	—	—	—	1	0·40	—	—
39·5	—	—	—	—	—	—	—	—	—	—
40·5	—	—	—	—	—	—	1	0·40	—	—
43	—	—	—	—	—	—	2	0·81	—	—
45	1	0·09	—	—	—	—	—	—	—	—
46	—	—	—	—	1	0·09	—	—	—	—
Totals	1094	99·85	755	99·92	1073	99·93	244	99·91	718	—

Horse Channel and No. 6 Area, 6-inch mesh, 1910.

	April.		May.		June.		July.		August.		September.		October.	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
11·5	—	—	1	0·04	—	—	—	—	—	—	—	—	—	—
12·5	—	—	1	0·04	—	—	—	—	—	—	—	—	—	—
13·5	5	0·38	1	0·04	—	—	—	—	—	—	—	—	—	—
14·5	8	0·62	4	0·17	1	0·15	1	0·26	—	—	—	—	—	—
15·5	24	1·84	18	0·78	3	0·44	—	—	3	0·08	—	—	—	—
16·5	94	7·24	67	2·86	15	2·20	6	1·57	12	0·33	—	—	1	0·46
17·5	159	12·25	200	8·53	37	5·44	26	6·82	48	1·34	8	2·00	2	0·92
18·5	232	17·86	363	15·48	124	18·24	45	11·81	189	5·26	11	2·75	11	5·09
19·5	217	16·71	432	18·43	140	20·59	50	13·12	311	8·66	25	6·26	13	6·02
20·5	183	14·09	382	16·29	132	19·41	56	14·70	392	10·91	43	10·77	8	3·70
21·5	124	9·55	291	12·41	70	10·29	34	8·92	413	11·50	51	12·77	18	8·33
22·5	84	6·47	253	10·76	61	8·97	38	9·97	411	11·45	36	9·02	7	3·24
23·5	55	4·23	144	6·14	42	6·17	40	10·50	400	11·14	32	8·02	9	4·17
24·5	49	3·77	88	3·75	28	4·12	40	10·50	373	10·39	47	11·78	14	6·48
25·5	24	1·84	50	2·13	11	1·61	17	4·46	270	7·52	38	9·52	16	7·40
26·5	17	1·31	17	0·72	5	0·73	15	3·94	292	8·13	28	7·02	22	10·18
27·5	13	1·00	15	0·64	4	0·62	5	1·31	186	5·18	29	7·27	19	8·80
28·5	5	0·38	8	0·35	2	0·30	3	0·79	147	4·09	19	4·76	22	10·18
29·5	2	0·15	2	0·09	3	0·44	2	0·52	66	1·84	19	4·76	18	8·33
30·5	2	0·15	3	0·13	—	—	2	0·52	39	1·08	5	1·25	12	5·55
31·5	—	—	3	0.13	1	0·15	—	—	16	0·44	3	0·75	9	4·17
32·5	—	—	2	0·09	—	—	—	—	11	0·31	1	0·25	9	4·17
33·5	1	0·08	—	—	—	—	—	—	4	0·11	2	0·50	4	1·85
34·5	—	—	—	—	—	—	1	0·26	4	0·11	—	—	—	—
35·5	—	—	—	—	—	—	—	—	4	0·11	1	0·25	1	0·46
37·5	—	—	—	—	—	—	—	—	—	—	—	—	1	0·46
38·5	—	—	—	—	—	—	—	—	—	—	1	0·25	—	—
41·5	—	—	—	—	1	0·15	—	—	—	—	—	—	—	—
Totals	1298	99·92	2345	100·00	680	100·02	381	99·97	3591	99·98	399	99·95	216	99·96

Beaumaris Bay and Red Wharf Bay Area, 6 inch net, 1910.

	January		March		April		June		July		August	
	No.	%	No.	%	No.	%	No.	%	No.	%	No,	%
9·5	—	—	1	0·13	—	—	—	—	—	—	—	—
10·5	—	—	—	—	—	—	—	—	—	—	—	—
11·5	—	—	2	0·25	—	—	—	—	—	—	—	—
12·5	—	—	1	0·13	—	—	—	—	—	—	—	—
13·5	4	0·33	7	0·89	2	1·94	—	—	—	—	—	—
14·5	9	0·75	7	0·89	5	4·85	1	0·09	—	—	—	—
15·5	22	1·84	13	1·66	13	12·62	9	0·81	1	0·19	—	—
16·5	35	2·93	53	6·79	6	5·82	22	1·99	5	0·97	—	—
17·5	56	4·68	87	11·15	24	23·30	112	10·15	27	5·24	2	1·94
18·5	71	5·93	87	11·15	18	17·48	126	11·41	70	13·59	7	6·79
19·5	70	5·86	74	9·48	10	9·71	109	9·87	74	14·36	10	9·71
20·5	57	4·77	55	7·05	6	5·82	105	9·51	55	10·68	7	6·79
21·5	63	5·27	53	6·79	2	1·94	64	5·79	31	6·02	6	5·82
22·5	71	5·93	67	8·59	3	2·91	52	4·71	30	5·83	11	10·68
23·5	55	4·60	72	9·23	2	1·94	35	3·17	33	6·40	10	9·71
24·5	53	4·43	43	5·51	3	2·91	46	4·17	16	3·11	9	8·73
25·5	62	5·19	42	5·38	2	1·94	42	3·80	21	4·08	9	8·73
26·5	71	5·93	29	3·72	2	1·94	34	3·08	22	4·27	8	7·76
27·5	81	6·78	27	3·46	1	0·95	38	3·44	21	4·08	5	4·85
28·5	62	5·19	19	2·43	—	—	45	4·08	22	4·27	5	4·85
29·5	65	5·44	17	2·18	1	0·95	39	3·53	21	4·08	4	3·88
30·5	68	5·69	6	0·77	2	1·94	41	3·72	12	2·33	2	1·94
31·5	62	5·19	9	1·15	—	—	39	3·53	16	3·11	4	3·88
32·5	44	3·68	4	0·51	—	—	51	4·62	15	2·91	2	1·94
33·5	28	2·34	1	0·13	—	—	35	3·17	9	1·75	1	0·95
34·5	34	2·93	1	0·13	—	—	17	1·54	3	0·58	1	0·95
35·5	14	1·17	1	0·13	—	—	16	1·45	6	1·16	—	—
36·5	14	1·17	—	—	—	—	6	0·54	2	0·38	—	—
37·5	2	0·16	2	0·25	1	0·95	5	0·45	1	0·19	—	—
38·5	3	0·25	—	—	—	—	4	0·36	1	0·19	—	—
39·5	5	0·42	—	—	—	—	6	0·54	—	—	—	—
40·5	3	0·25	—	—	—	—	5	0·45	—	—	—	—
41·5	2	0·16	—	—	—	—	—	—	1	0·19	—	—
42·5	1	0·08	—	—	—	—	—	—	—	—	—	—
43·5	1	0·08	—	—	—	—	—	—	—	—	—	—
44·5	1	0·08	—	—	—	—	—	—	—	—	—	—
45·5	1	0·08	—	—	—	—	—	—	—	—	—	—
46·5	1	0·08	—	—	—	—	—	—	—	—	—	—
47·5	1	0·08	—	—	—	—	—	—	—	—	—	—
48·5	1	0·08	—	—	—	—	—	—	—	—	—	—
56·5	1	0·08	—	—	—	—	—	—	—	—	—	—
	1194	99·90	780	99·93	103	99·91	1104	99·97	515	99·95	103	99·90

	Beaumaris Bay and Red Wharf Bay area, 6 inch net, 1910.							Menai Straits, 6 inch net, 1910.		
	Sept.		Oct.	Nov.		Dec.		Jan.	Feb.	Mar.
	No.	%	No.	No.	%	No.	%	No.	No.	No.
13·5	—	—	—	2	0·06	1	0·12	—	1	—
14·5	—	—	—	10	0·30	8	0·93	—	—	—
15·5	—	—	—	50	1·49	9	1·05	—	1	—
16·5	—	—	1	94	2·80	28	3·27	—	10	2
17·5	5	1·70	3	94	2·80	28	3·27	5	17	5
18·5	16	5·46	9	130	3·88	43	5·03	8	22	2
19·5	24	8·19	5	144	4·30	48	5·61	9	14	2
20·5	20	6·82	2	202	6·03	52	6·08	5	14	3
21·5	14	4·77	8	209	6·24	73	8·53	8	17	2
22·5	23	7·85	6	221	6·60	64	7·48	10	6	1
23·5	15	5·10	8	214	6·39	69	8·06	9	5	1
24·5	16	5·46	8	201	6·00	38	4·44	3	4	—
25·5	22	7·51	8	199	5·94	51	5·96	5	2	—
26·5	16	5·46	5	211	6·30	56	6·55	6	3	—
27·5	28	9·55	7	200	5·97	57	6·66	2	2	1
28·5	19	6·48	2	259	7·73	58	6·78	1	2	—
29·5	22	7·51	5	269	8·04	45	5·26	3	1	—
30·5	15	5·10	3	210	6·27	56	6·55	—	3	—
31·5	9	3·07	—	129	3.85	25	2·92	2	—	—
32·5	12	4·10	—	109	3·26	22	2·57	1	1	1
33·5	7	2·38	—	55	1·64	5	0·58	—	—	—
34·5	7	2·38	—	51	1·52	7	0·82	—	—	—
35·5	—	—	—	31	0·92	2	0·24	1	2	—
36·5	1	0·34	—	23	0·69	1	0·12	—	—	—
37·5	2	0·68	—	7	0·21	2	0·24	1	1	—
38·5	—	—	—	5	0·15	2	0·24	—	—	—
39·5	—	—	—	7	0·21	4	0·48	—	—	—
40·5	—	—	—	4	0·15	—	—	—	—	—
41·5	—	—	—	3	0·09	1	0·12	—	—	—
42·5	—	—	—	2	0·06	—	—	—	—	—
43·5	—	—	—	1	0·03	—	—	—	—	—
44·5	—	—	—	—	—	—	—	—	—	—
45·5	—	—	—	1	0·03	—	—	—	—	—
46·5	—	—	—	—	—	—	—	—	—	—
47·5	—	—	—	1	0·03	—	—	—	—	—
Totals	293	99·91	80	3348	99·98	855	99·96	79	128	20

Carnarvon Bay, 6 inch net, 1910.

	April.	May	June.	July	Septem.	Oct.
	No.	No.	No.	No.	No.	No.
12·5	—	—	—	—	—	—
13·5	—	—	—	—	—	—
14·5	—	—	—	—	—	—
15·5	—	—	—	—	—	—
16·5	—	—	—	2	3	1
17·5	—	—	3	5	52	2
18·5	1	6	13	9	23	4
19·5	—	3	12	11	22	1
20·5	3	8	5	23	28	—
21·5	4	6	2	14	19	2
22·5	3	7	—	5	17	4
23·5	6	10	1	4	31	4
24·5	5	7	1	4	24	11
25·5	4	5	—	2	9	8
26·5	1	2	—	2	10	5
27·5	4	3	—	3	14	7
28·5	1	2	—	3	14	8
29·5	—	3	—	1	22	—
30·5	4	1	—	1	6	6
31·5	4	1	—	—	—	—
32·5	—	—	—	—	5	1
33·5	—	—	—	—	—	2
34·5	2	—	—	—	1	1
35·5	—	—	—	1	—	1
36·5	—	—	—	—	—	—
37.5	1	—	—	—	—	1
38·5	—	—	—	—	1	2
39·5	—	—	—	—	—	—
40·5	—	—	—	—	—	—
41·5	—	—	—	—	—	—
Totals ...	43	64	37	90	301	71

Cardigan Bay, near New Quay Head, 6 inch net, 1910.

	April.	July.	August.	September.
	No.	No.	No.	No.
15·5	—	—	—	1
16·5	—	1	1	—
17·5	10	—	1	—
18·5	11	6	3	2
19·5	7	8	2	3
20·5	11	21	3	5
21·5	10	18	6	17
22·5	10	18	2	11
23·5	4	23	5	17
24·5	18	23	—	17
25·5	18	18	4	15
26·5	13	20	3	14
27·5	14	16	1	9
28·5	11	13	1	10
29·5	5	2	1	5
30·5	3	3	—	3
31·5	2	1	—	5
32·5	1	—	—	2
33·5	—	—	—	2
34·5	—	—	—	—
35·5	—	—	—	—
36·5	—	—	—	—
37·5	—	—	—	—
38·5	—	—	—	—
Totals	148	191	33	138

Age Groups, 1910, near Nelson Buoy.

	May.								June.						July.							
	♂				♀				♂			♀			♂				♀			
	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1	2	3	4	1	2	3	4
12·5																						
13·5																						
14·5									1				1									
15·5										1		1			1				1			
16·5	1					1			1			2								3		
17·5						1			4	6		1	3			2				1		
18·5		1							4	8		4	7		1	5				4		
19·5						1			1	9		1	4			7	1		1	3		
20·5		1							1	12	1		14			4				3		
21·5	1	4				1				10			8	1		9				11		
22·5	1	3	1			4				6			7	2		9				7		
23·5		2								6	1		4	1		5				7		
24·5		3	1			1	2			8	1		2			2				1		
25·5		3	2				4						4	2		7	1			3		
26·5		1	1				1			1			1	1		2	1			2		
27·5			2				1			2				1						1	1	
28·5			2										2			1		1				
29·5			2										1									
30·5								1														
31·5													1									
32·5																						
36·5								1														

Age Groups, 1910, near Nelson Buoy—*Continued.*

	August.							September.				October.					November.					
	♂				♀			♂		♀		♂			♀		♂			♀		
	1	2	3	4	1	2	3	1	2	1	2	1	2	3	1	2	1	2	3	1	2	3
12·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
13·5	2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
14·5	1	......	......	......	......	......	......	......	......	......	......	1	......	......	1	......	1	......	......	......	......	......
15·5	1	1	......	......	3	1	......	2	......	2	......	......	......	......	1	......	1	......	......	1	......	......
16·5	6	......	......	......	3	1	......	5	......	6	......	1	......	......	2	......	1	......	......	7	......	......
17·5	1	2	......	......	4	1	......	3	......	9	......	6	1	......	3	......	2	......	......	5	......	......
18·5	2	3	......	......	2	......	......	8	2	8	2	2	......	......	5	......	......	2	......	1	1	......
19·5	3	3	......	......	......	......	......	1	1	6	3	4	1	......	6	2	3	1	......	3	1	......
20·5	......	5	......	......	......	2	......	6	5	......	1	5	......	......	3	2	......	......	......	1	2	1
21·5	......	5	......	......	......	5	......	2	2	......	3	1	6	1	1	3	4	......	......	......	......	......
22·5	......	4	......	......	......	6	1	1	2	1	2	4	5	......	2	4	......	......	......	......	1	......
23·5	1	4	......	......	......	4	......	......	6	1	2	1	2	......	1	2	1	......	......	......	2	......
24·5	......	6	1	1	......	4	1	......	3	......	2	2	11	......	2	5	......	2	......	......	2	......
25·5	......	1	......	......	......	5	1	......	3	......	1	......	6	......	1	2	......	4	......	......	2	......
26·5	......	3	......	......	......	2	......	......	1	......	2	......	3	......	......	1	......	3	......	......	1	1
27·5	......	1	......	......	......	2	......	......	......	......	2	......	4	......	......	......	......	6	......	......	2	......
28·5	......	1	......	......	......	1	......	......	......	......	......	......	1	......	......	......	......	3	......	......	1	......
29·5	......	......	......	......	......	......	1	......	......	......	1	......	......	......	......	......	......	1	......	......	4	......
30·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	1	......	......	3	......
31·5	......	......	......	......	......	......	1	......	......	......	......	......	......	......	......	1	......	2	1	......	1	......
32·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1
36·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1

Age Groups, 1910, off Mersey Estuary.

	May.						July.					September.					October.					November.					
	♀			♂			♀			♂		♀			♂		♀			♂		♀			♂		
	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	1	2	3	1	2	1	2	3	1	2	3
12·5	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14·5	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15·5	...	1	...	1	1	...	...	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16·5	1	...	...	...	1	...	2	...	...	4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
17·5	...	1	...	2	5	...	2	1	...	4	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
18·5	1	1	...	1	3	...	3	3	...	5	2	1	...	...	...	1	2	...	...	2	...	1	...	...	...	...	...
19·5	1	4	...	...	1	...	1	6	...	...	4	...	...	...	1	...	3	...	...	1	...	1	...	...	1	...	...
20·5	...	6	...	...	9	...	...	7	...	...	16	3	...	...	9	...	3	...	...	1	...	1	...	...	...	...	...
21·5	...	4	...	...	3	...	...	10	1	...	10	4	2	...	5	1	2	...	...	1	...	...	...	...	...	3	...
22·5	...	1	1	...	2	...	...	11	2	...	7	1	1	...	4	1	2	...	...	1	...	...	2	...	...	3	...
23·5	...	6	...	...	3	1	...	6	...	...	4	...	2	...	1	2	1	...	...	4	1	...	1	...	1	2	...
24·5	...	2	...	...	1	...	...	2	...	...	1	1	1	...	...	1	2	1	...	1	1	1	1	...	1	1	...
25·5	...	...	...	...	...	...	...	2	1	...	2	...	...	...	...	2	1	...	...	...	3	...	1	...	...	2	...
26·5	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...	1	...	...	...	...	2	...	...	...	...
27·5	...	...	...	...	...	...	...	...	...	...	1	...	2	...	...	...	...	...	...	...	1	...	1	...	...	...	...
28·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	...	...
29·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...
30·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...
31·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
32·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
33·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...
34·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...

Age Groups, 1910, Barrow Channel.

	March.					May.						June.					July.					November.					
	♂		♀			♂			♀			♂		♀			♂			♀		♂			♀		
	1	2	1	2	3	1	2	3	1	2	3	1	2	1	2	3	1	2	3	1	2	1	2	3	1	2	3
14·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	1	......	......	3	......	1	......	......	......	......	......
15·5	6	......	......	......	......	......	1	......	......	......	......	......	1	1	1	......	5	......	......	4	......	5	......	......	5	......	......
16·5	19	21	1	3	......	1	......	......	1	1	......	1	5	1	3	......	5	1	......	4	2	11	1	......	7	......	......
17·5	25	27	3	4	......	......	1	......	......	1	......	......	7	......	6	......	6	3	......	2	1	11	6	......	10	4	......
18·5	20	8	8	8	......	1	1	......	2	5	......	......	12	......	9	......	......	5	......	1	4	5	5	......	3	3	......
19·5	16	3	2	4	1	1	4	......	1	3	......	......	3	......	11	......	1	3	......	1	5	1	6	1	1	2	4
20·5	3	4	5	2	......	......	6	......	......	1	......	1	10	......	5	......	......	5	......	......	9	......	7	1	2	6	3
21·5	......	......	1	1	......	......	4	......	......	9	......	......	5	......	6	......	......	5	1	......	5	1	3	1	1	2	......
22·5	......	......	......	2	......	......	1	1	......	3	......	......	4	......	1	1	......	6	......	......	3	......	3	......	......	6	2
23·5	......	......	......	1	......	......	6	......	......	2	......	......	1	......	2	......	......	4	......	......	2	......	3	......	......	3	......
24·5	......	......	......	......	......	......	2	......	......	3	1	......	1	......	3	......	......	2	......	......	2	......	......	......	......	1	1
25·5	......	......	......	......	1	......	......	......	......	1	......	......	......	......	......	......	......	......	......	......	......	......	2	......	......	1	......
26·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......	1	1	......	1	......
27·5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	2	......

Age Groups, 1910. Beaumaris and Red Wharf Bays.

	June.							July.										September.					
	♂			♀				♂				♀					♂			♀		
	2	3	4	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	1	2	3
10·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
12·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
13·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
14·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15·5	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
16·5	5	...	...	7	...	...	...	...	1	...	...	1	...	...	...	...	...	...	...	...	...	...
17·5	8	...	...	11	...	...	...	...	5	...	...	...	2	...	...	...	1	...	...	...	1	...
18·5	8	...	...	7	...	...	...	...	6	1	...	...	5	1	...	...	...	4	...	...	1	...
19·5	4	...	...	9	...	...	...	...	6	...	...	...	7	1	...	...	...	4	...	...	2	...
20·5	6	...	...	5	...	...	...	...	2	...	...	...	6	...	...	...	...	1	...	1	1	...
21·5	5	...	...	4	...	...	...	...	2	...	...	...	2	1	...	...	...	2	...	...	4	...
22·5	2	1	...	3	...	...	...	...	5	...	...	...	3	1	...	...	...	7	...	...	5	...
23·5	3	1	...	4	...	...	...	...	3	2	...	...	5	...	...	...	...	4	...	...	7	...
24·5	2	2	...	...	2	...	...	...	6	1	...	...	1	1	...	...	...	5	...	...	5	1
25·5	1	1	...	2	3	...	...	...	...	1	...	...	...	2	...	...	...	3	...	...	6	1
26·5	1	2	...	...	2	...	...	...	...	1	...	...	1	3	...	...	...	2	4	...	7	...
27·5	...	3	...	1	2	1	...	...	1	3	...	...	1	3	...	...	...	5	8	...	4	4
28·5	1	3	...	...	1	...	...	...	1	4	...	...	1	3	...	...	...	2	2	...	4	2
29·5	...	2	...	...	3	...	...	...	1	4	...	...	1	4	...	...	...	...	1	...	...	1
30·5	...	2	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	...	3	...	...	1
31·5	1	2	...	...	2	...	...	...	...	...	1	...	...	3	...	...	...	...	1	...	...	2
32·5	...	5	...	...	4	...	...	...	...	1	...	...	...	4	...	...	...	...	...	...	...	...
33·5	...	1	1	...	3	...	...	...	...	...	1	...	...	3	...	...	...	...	...	...	...	...
34·5	...	1	...	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...
35·5	...	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
36·5	...	...	...	...	...	...	...	...	...	1	...	...	...	1	...	1	...	...	...	...	...	...
37·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
38·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
39·5	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
40·5	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
41·5	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
42·5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Age Groups, 1910. Beaumaris and Red Wharf Bays—*Continued.*

	October.									November.							December.					
	♂				♀					♂				♀			♂			♀		
	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	1	2	3	1	2	3
10·5											1											
11·5																						
12·5																						
13·5																						
14·5					2										1		3					
15·5	2	4			1	3					1			1	3		2	1		1		
16·5	1	1				4				3	3			1	2		1	1		3		
17·5		7				3				1	4			5	3		2	3		3		
18·5		3				8					6			2	5		7	5		2	4	
19·5	1	2	1			4	4				8	1		1	7		3	3		2	6	
20·5	2	1	1			7	1			1	6			1	2	1		2		2	7	
21·5		1	1			1	4				7	5		3	9	1	1	8		2	9	
22·5			1			2	5				5	3			10	4		1		3	4	
23·5		2	1			1	1			2	7	1		3	5			3	1	2	5	
24·5			1			2	2				4	1		1	6	4		3			3	
25·5						1	4				1		1		4	2		2			3	
26·5						2					4	2			2	2		1				
27·5		2	1			2					4	2			3			3				
28·5			1								3	3			3	2			2			
29·5			1								2	1			4	2						
30·5			1										1		2	1						
31·5			1				1					1			2						2	
32·5												1	1		1	1						
33·5			1													2						
34·5				2			1				1											1
35·5																						
36·5							1															
37·5																						
38·5													1			1						
39·5																						
40·5																						
41·5								1	1													
42·5									1													

Values of the Length–Weight Coefficient κ

1910.

	Barrow Channel.	Near Nelson Buoy.	Near Mersey Estuary.	Beaumaris and Red Wharf Bays.
January	—	—	—	—
February	—	—	—	—
March	0·977	—	—	—
April	—	—	—	—
May	—	1·05	1·11	—
June	1·22	1·07	—	1·01
July	1·18	1·11	1·11	1·01
August	—	1·06	1·09	—
September	—	1·05	1·16	0·986
October	—	0·997	1·13	—
November	0·949	1·07	1·12	1·04
December	—	—	—	—

Plaice measured twice.

A—immediately after capture: B—24 hours after.

Mean length.	A No.	B No.	Mean length.	A No.	B No.
13·5	3	3	28·5	43	39
14·5	9	10	29·5	39	31
15·5	27	32	30·5	19	15
16·5	51	61	31·5	15	21
17·5	97	102	32·5	20	18
18·5	111	122	33·5	8	11
19·5	124	119	34·5	13	6
20·5	104	105	35·5	6	6
21·5	121	116	36·5	2	2
22·5	137	128	37·5	2	2
23·5	97	105	38·5	3	3
24·5	104	101	39·5	—	—
25·5	75	67	40·5	—	1
26·5	60	58	41·5	2	1
27·5	55	64	42·5	1	—
—	—	—	47·5	1	1

3. Appendix on Statistical Methods.

The following mathematical methods are well-known ones, but it interesting to consider their application to the data of fishery statistics.

(1) *Frequency Curves.*

Almost any one of the series of measurements of the lengths of the plaice composing a catch may be graduated in such a way as to give (apart altogether from the bias of the worker) a very regular series of figures, or a very smooth curve. Prof. Pearson's now well-known probability curve may be employed for this purpose and the method involves finding various moments of inertia, about the mean of the series, for each unit of length in the series. Constants obtained from these values can then be employed to determine the particular type of probability curve best fitting the rough data, and the constants to be used in the equation found are also so obtained. We shall see that not every series of length-frequency measurements can be so manipulated—at least with success—but many can. I give examples of three such theoretical frequency-distributions, and also charts which represent graphically the original data and the smoothed figures.*

Three types of frequency curve have been found--possibly there may be others.

Type I, that is

$$y = y_0 \left(1 + \frac{x}{a_1}\right)^{m_1} \left(1 - \frac{x}{a_2}\right)^{m_2}$$

where $\frac{m_1}{a_1} = \frac{m_2}{a_2}$

The curve is asymmetrical about the mode, and it is limited in either direction. It rises steeply from the beginning (a_1) and then falls more slowly towards the

*It is proper that one should acknowledge with gratitude the very clear and practical summary of Pearson's method given by W. Palin Elderton.—"Frequency Curves and Correlation." C. & E. Layton, London, 1906.

end (a_2). The net so operates as not to catch any fish above and below certain limits of length. Obviously the majority of plaice catches made by the 6-inch mesh trawl net and nets of wider mesh may be represented by this curve. The lower limit is determined by the condition that the smaller fish escape through the meshes of the net; the upper limit in these catches represents the upper limit of length of the population sampled.

The table on this page, and the chart (Fig. 1) represent a catch of this kind, consisting of 3,591 plaice caught by the same fisherman and vessel in the Horse Channel, off Liverpool, in August, 1910.

Type I. 3,591 plaice from Horse Channel, Mersey Estuary, August, 1910; 6-inch trawl-mesh.

Mean length cms.	Observed frequency	Calculated frequency	Constants.
15·5	3	imaginary	
16·5	12	11·14	$N=3591$
17·5	48	69·66	$d=1·80451$
18·5	189	162·32	$\mu_2=10·040874$
19·5	311	268·13	$\mu_3=13·3703$
20·5	392	352·83	$\mu_4=288·51$
21·5	413	404·03	$\beta_1=0·181063$
22·5	411	416·55	$\beta_2=2·85942$
23·5	400	393·84	$\kappa=-0·173$
24·5	373	346·74	$r=12·21583$
25·5	270	286·28	$b=24·8491$
26·5	292	220·82	$m_2=7·453844$
27·5	186	161·15	$m_1=2·761981$
28·5	147	110·99	$a_2=18·1308$
29·5	66	70·85	$a_1=6·7183$
30·5	39	41·83	$y_0=417·9071$
31·5	16	19·42	$Mean=23·30$
32·5	11	9·26	$Mode=22·37$
33·5	4	3·12	
34·5	4	1·34	
35·5	4	0·37	

In this, and other tables the notation is that given by W. Palin Elderton (*Op. cit.*)

The moments given in the table are unadjusted but the calculation was made from adjusted moments.

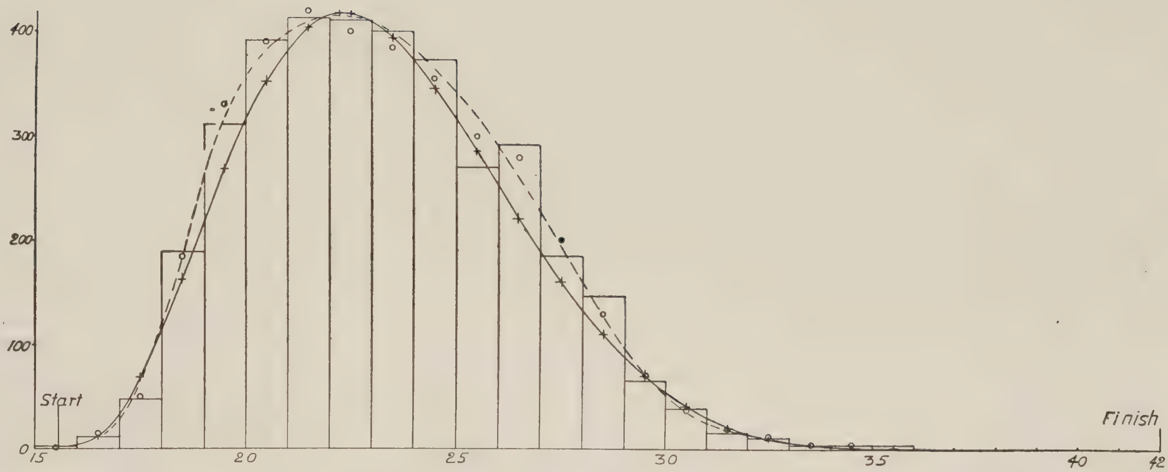


FIG. 1. A catch of 3,591 plaice, Mersey area, August, 1910. The columns represent the actual frequencies considered as areas. The unbroken line is the frequency curve. The broken line has been drawn by integrating the actual frequencies; mean lengths in centimetres on horizontal axis. Type I.

TYPE IV, that is

$$y=y_0\left(1+\frac{x^2}{a^2}\right)^{-m} e^{-\nu \tan^{-1}\frac{x}{a}}$$

The limiting form of Type I is a curve which is symmetrical but limited in both directions. We do not often find such distributions among plaice catches, and none of the series analysed falls into this group. Instead of such a type we find the above one where the curve is asymmetrical and has branches extending to infinity in either direction. The natural conditions giving such a distribution are the presence on the fishing ground of plaice with a considerable range of sizes; and the partial choking of the meshes of the net with sea-weed and other débris. Some of the smaller fish which would otherwise escape are thus caught; on the other hand, the larger fish are able to swim out from the net because of the decreased draught of water through its meshes—obviously the smaller fish are not so able to do this. In a catch of this kind one cannot deduce the range of lengths of the fish forming the population sampled by the net, and the calculation of a standard deviation would probably be attended by a larger error than the statistical method would indicate.

The table on the following page represents the theoretical distribution of lengths in several catches (1,593 fish) of plaice made in Barrow Channel in June, 1910, by a second-class sailing vessel employing a trawl-net of 6-inch mesh. It will be noticed that the frequencies are not tabulated for equidistant values of x, the reason being that—to avoid labour—the equation was put in the form

$$\begin{cases} x = a \tan \theta \\ y = y_0 \cos^{r+2}\theta \, e^{-\nu\theta} \end{cases}$$

and arbitrary values of the argument were thus chosen. The chart on p. 212 (Fig. 2) represents both the original data, and the curve plotted from the theoretical frequencies. The approximate expression for y_0 given by Elderton was employed. The curve is not far from being symmetrical, and Type II might have been used, but we should then have missed deducing the action of the fishing gear from the form of the curve.

TYPE IV. 1,593 plaice from Barrow Channel, June, 1910; 6-inch trawl-mesh.

Mean length cms. (x)	Observed frequency (y)	Calculated frequency (x)	Calculated frequency (y)	Constants.
14·5	6	14·45	4·67	$N=1593$
15·5	15	15·79	18·74	$d=0·394852$
16·5	40	16·81	48·75	$\mu_2=5·340012$
17·5	89			$\mu_3=3·75915$
18·5	177	18·13	132·44	$\mu_4=112·3545$
19·5	203	18·75	187·51	$\beta_1=0·0928009$
20·5	315	19·98	280·96	$\beta_2=3·9400$
21·5	260	20·23	290·83	$\kappa=0·045$
22·5	239	20·60	297·35	$r=10·66631$
23·5	130	20·86	295·82	$m=6·333155$
24·5	62	21·25	284·73	$\nu=-2·317109$
25·5	31	21·92	245·79	$a=7·020828$
26·5	9	22·64	190·1	$y_0=240·9106$
27·5	8	24·28	79·282	*Mean* = 20·89485
28·5	4	26·39	18·868	*Mode* = 20·65403
29·5	2			*Origin* = 19·369677
30·5	2			
31·5		31·53	0·435	
32·5				
35·5	1			

TYPE VI, that is

$$y = y_0 (x-a)^{q_2} x^{-q_1}$$

Here we have an asymmetrical curve, limited in one direction. The range is from a lower limit (a) to infinity. The example is a series of measurements of plaice caught in a shrimp trawl net of ½-inch mesh. The lower limit a is 14·108 − 10·139, that is 3·96 centimetres, and this is probably the actual lower limit of the plaice present on the ground at the time (January), since the mesh of the

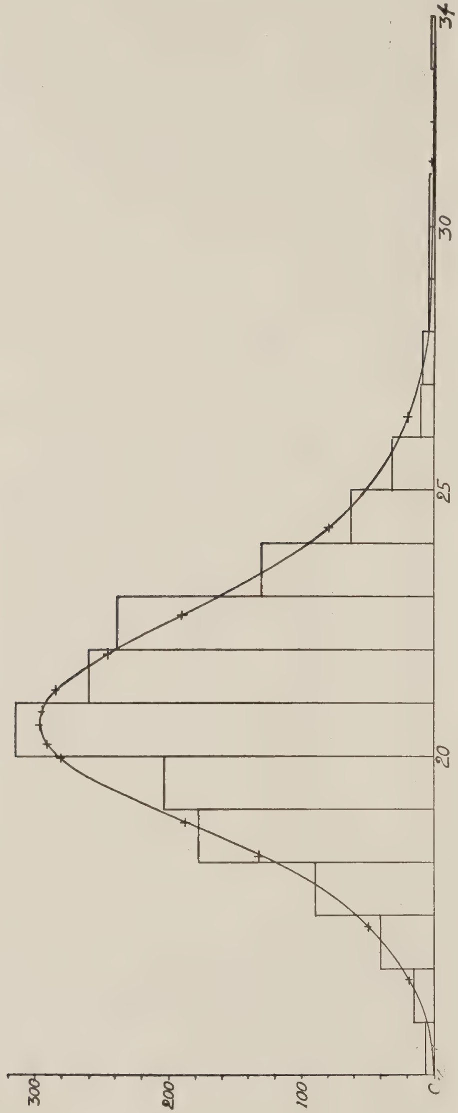


Fig. 2. Catch of 1,593 plaice from Barrow Channel. Type IV.

net was small enough to catch all the smaller fish present, and it is otherwise highly probable that no plaice much less than 4 centimetres in length could have been present at the time. On the other hand, the upper limit is indefinite, since the larger plaice were easily able to swim back out from the net on account of the restricted draught of water through the narrow meshes. We know, of course, that larger plaice than those caught must have been present on the ground. The form of the curve does not, of course, mean that the plaice were infinitely large, but just that the decrease in the numbers captured varies as if the range were infinite.

Type VI. 5,057 plaice from off Mersey Estuary, January 1909; shrimp trawl-net ($\frac{1}{2}$-inch mesh).

Mean length cms.	Observed frequency.	Calculated frequency.	Constants.
4·5	113	13·84	$N=5057$
5·5	1168	1197·45	$d=0·776943$
6·5	1487	1336·90	$\mu_2=3·514413$
7·5	920	949·71	$\mu_3=10·875396$
8·5	601	575·27	$\mu_4=98·07792$
9·5	401	326·09	$\beta_1=2·724768$
10·5	168	179·66	$\beta_2=7·940757$
11·5	80	98·15	$k=2·024$
12·5	36	53·69	$r=—14.81712$
13·5	30	29·59	$q_1=18·82236$
14·5	16	16·44	$q_2=2·00524$
15·5	16	9·29	$a=14·10833$
16·5	10	5·31	$Log\ \Gamma\ (q_1)=15·56691$
17·5	7	3·07	$Log\ \Gamma\ (q_1-q_2-1)=11·8944$
18·5	1	1·80	$Log\ \Gamma\ (q_2+1)\ =0·30919$
19·5	3	1·07	$Mean=7·276943$
			$Mode=5·72974$
			$Log\ y_0=25·248629$
The ordinate at the mode is 1396·7.			

Fig. 3, p. 214, is the graph of the rough and the smoothed data. The latter are given in the above table.

(2) *"Smoothing" empiric curves.*

If the preceding tables of frequency distributions be examined, still better if the graphs be examined, it will be seen that the calculated values do not "fit" very closely to the observed values. This is, indeed, not to be expected, since the observed values must necessarily deviate to either side of a mean; but it will be noticed that the areas of the two figures formed by plotting observed and calculated ordinates are not the

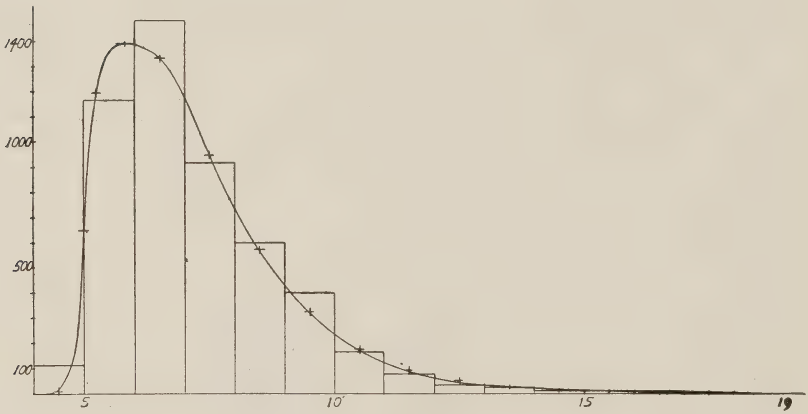


FIG. 3. 5,057 plaice from Mersey area, January, 1909.

same. The difference is not due entirely to the roughness of the original data, for when the larger series are considered the difference in areas still is apparent. It may be due, to some extent, to the difficulty in making the statistical "adjustments," but this is not the only source of difference. There is no doubt that the statistical data are not homogeneous and that the roughness of the smaller distributions may conceal this; but that while the roughness may disappear in the larger distributions, the heterogeneity remains, and makes a bad-fitting theoretical curve.*

There is no doubt that a catch of plaice, even one made by an experienced fisherman in such a way as to ensure regular action of the trawl net, contain heterogeneous material; for we have only to determine the ages of the individual fishes to see that the catch contains fish of at least two age-groups. In the majority of the catches tabulated in this Report, age-groups I, II and III are present, that is, groups differing by one complete year of age. Now the mean difference in length of plaice of successive years of age, within the range represented by these records, may be taken as about five centimetres; and this difference is sufficient, when two groups are present in approximately the same proportions, to prevent the close fit of a frequency curve to the rough data. For the meaning of a theoretical frequency curve is that, in a series of measurements of one variable character in a great number of individuals of the same species, the deviations on either side of the mean follow one of a few probability laws, each of which, as experience has shown, can be represented by an algebraic or transcendental formula. But if the series of measurements include those of the same character in two species mixed together in the material examined, the distribution obviously cannot be expressed by the same probability formula. (By "species" is meant a distinct kind of thing differing in some respect from another.)

If the number of measurements is relatively small (say 500), and if the sample contains fish which belong mostly to one age-group, a fairly close fit might be obtained. But when there are approximately equal

* See Palin Elderton, *Op. cit.*, p. 143.

numbers of fish belonging to two successive age-groups, and when few fish of other groups are present, a complex curve should result. The latter would be complex even if plotting the original data gave an apparently uni-modal curve.

In making use of Professor Pearson's methods for the representation of fish measurement series, we should, then, first of all separate the series into as many groups as there are distinct years of age among the fish caught. This would involve the dissection of every specimen measured—an impracticable proceeding generally. But in many of the catches of plaice made in the Irish Sea one age-group is predominant, and in such cases it seems that a Pearsonian frequency formula may be applied without serious error. The graduated statistics thus obtained would be a better expression of the actual distribution than the rough data. Such a sample is represented by the catch of plaice treated on p. 213, where the age-group O is the predominant one.

The following series of measurements represents a catch where an entirely different method must be employed.

The second and fourth column are graphed in the figure on p. 218.

In "smoothing" a rough series of figures the method of finding the mean of every three successive groups is usually adopted, that is any value,

$$Y = \frac{(y-1)+y+(y+1)}{3}$$

This would graduate the series in respect of the errors of measurement, for it is likely that some fish which ought to belong to group x are placed in groups $x-1$ or $x+1$. But it would not take account of larger errors such as the unequal distribution of the fish population. Further, the method is that of "proportional parts," and it is assumed that a change in the function is proportional to a change in the argument, and this may be very far from being the case when x changes by large

One haul of a 6 inch trawl net in Red Wharf Bay, 30th November, 1910.

Mean length	Nos. actually caught.	Integrated	Disintegrated from the curve.
16·5	12	2228	8
17·5	18	2216	28
18·5	55	2198	49
19·5	66	2143	78
20·5	125	2077	127
21·5	165	1952	153
22·5	165	1787	169
23·5	166	1622	176
24·5	173	1456	167
25·5	156	1283	163
26·5	181	1127	160
27·5	169	946	175
28·5	215	777	223
29·5	218	562	217
30·5	138	344	137
31·5	79	206	86
32·5	65	127	52
33·5	29	62	35
34·5	21	33	20
35·5	7	12	10
36·5	2	5	2
37·5	2	3	2
38·5	0	1	1
39·5	1	1	0
	2228		2238

increments. In such a case "smoothing" by this method would result in a displacement of the whole curve, its mode and phase being affected.

The method adopted in the example just given was, I think, suggested by Mr. A. L. Bowley. The actually occurring frequencies are summed so that any value of y in column 3 is given by

$$y_x = \sum_a^x y\delta x.$$

a being the end of the series. By working in this way we approximate to the value of the definite integral between any value of x and the end of the curve; but the increments δx are not very small (1 cm. in the example).

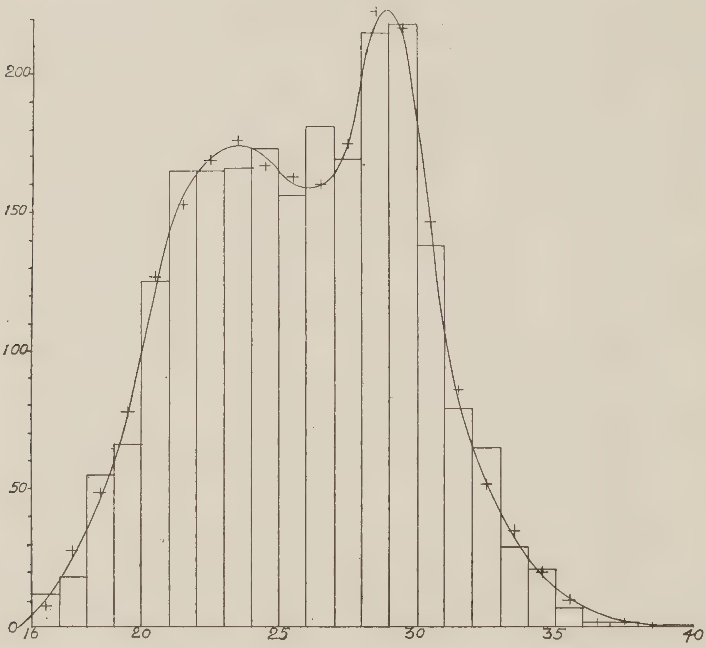


FIG. 4. A catch of 2,228 plaice from Red Wharf Bay, November, 1910.

The graph of the figures in column 3 can now be plotted with considerable accuracy, and if some mechanical means of drawing the curve be adopted, a fine clear line may be drawn, and there is no doubt, as a rule, as to how it ought to go. Values of y for each value of x are now read off on the curve, and if the latter is described carefully on a rather large scale, there is no difficulty in obtaining a series of figures which should sum up to very approximately the same value as the original (integrated) series. The original series is replaced by this graduated series, and then the process of integrating by summation is reversed. The figures in column 4 of the example are those on the same line in column 3a,* *minus* the figures of the line next below. The figures in column 4 can then be plotted: they do not form a perfectly smooth series, but there is never any doubt as to how the curve ought to be drawn.

This is probably the best method of smoothing such series as are here dealt with when an analytical expression for the function cannot be obtained. There are many plaice-measurement series which are obviously bi-modal: one sees this from inspection of the figures. Others cannot easily be so identified, but when they are integrated there is never any doubt as to the presence of two or more modes, and unless the integral curve shows more than one point of inflexion, one ought not to regard the series as bi-modal. Of course a curve might be drawn smoothly through the original figures plotted as points on a graph, but there would always be some bias displayed in so drawing the line.

Fig. 5 represents another example treated in this manner, and the dotted curve in fig. 1 represents the curve drawn by the same manner. In this last example it is easy to see that the frequency curve obtained by the method of moments differs considerably from that obtained by smoothing by graphical integration. The latter curve is not very accurately obtained, but it is

* The smoothed integrated series not given in the table.

very evident that it must differ considerably from the theoretical frequency curve, and I have no doubt that it represents the natural distribution of the population from which the sample was obtained with greater probability.

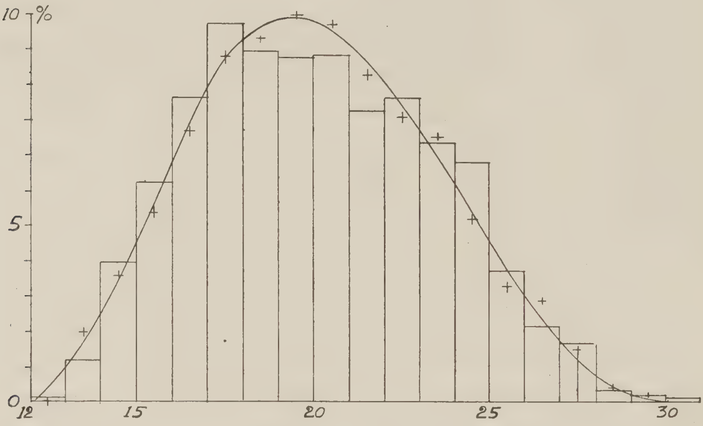


FIG. 5.

(3) *The length-weight formula for the Plaice.*

In the tables given in this and the preceding reports on plaice measurements the truth of the now well-known formula, $w = kl^3$, has been assumed. The length (l) of the fish is stated in centimetres; the weight (w) in grams; and k is a co-efficient which varies from 0·8/100 to 1·2/100, according to the fishing ground and season of the year. The co-efficient k has been calculated from the equation

$$k = \frac{100 \text{ (weight of the catch of plaice in grams)}}{\text{(sum of the cubes of the lengths in cents.)}}$$

The cubes of each centimetre group being found and multiplied by the number of cases in the group. The co-efficient varies from a minimum in December-February to a maximum in July-September. It also varies from ground to ground, and if its value is estimated for any particular ground from year to year it will be found to vary for corresponding months. It could be made use of to estimate the weights of plaice without weighing, but obviously the result so obtained would be approximate only. It is valuable from the point of view of affording perhaps the best general expression for the "condition" of the plaice inhabiting a fishing ground at a certain time of year. It will vary according to the reproductive phase if mature fish are dealt with, and according to the seasonal nutrition-phase if immature fish are dealt with.

The formula may also be used as a means of "smoothing" a curve representing the variation of weight with length in the case of a catch of plaice, but it is not very suitable for this purpose; for if one plots a series of points representing average weights and draws a curve as smoothly as possible through them, and then superposes a curve drawn from the formula, close agreement will not always be found. Generally speaking, the formula expresses with considerable accuracy the variation in weight within narrow limits (say 20 to 30 cms. of length), but for a catch of fish varying, say, from 15 to 35 cms. it will often fail.

One can easily conceive of many purposes for which length-frequency and length-weight curves and equations may be used by a fishery authority of the future, seeking for the most profitable continued yield of any species of edible fish from the grounds under its control. Such an authority would keep itself acquainted with the distribution of plaice on the grounds from season to season, by means of samples, and would have an accurate knowledge of the weights of fish landed from each ground for short periods of time. Even at the present time it has been necessary to find, from the weight of plaice landed, the approximate numbers of fish within, or above and below certain limits of size; and this has been done by the somewhat haphazard method of deducing "factors" which are used to convert the weight of fish contained in "boxes" or "trunks" into actual numbers. Given the length-frequency relation, and the length-weight relation, the numbers of plaice within any limits of length (a) and (b) could obviously be obtained from the total weight landed by means of the expression

$$G = \int_b^a \int_b^a f(x),\ \phi(x)\ dx\ dx$$

G being the total weight of the catch, or series of catches; $f(x)$ the length-frequency function; and $\phi(x)$ the length-weight function. Both are independent variables, but each is dependent on x (the length). The actual integration need not be made—as a rule it could only be made approximately—but tables might be used similar, in a way, to those employed by actuaries. By such means considerable accuracy of result could be obtained.

The length-frequency function can be obtained by analysis or empirically, with considerable accuracy, as shown above; but in such calculations one could not use the length-weight function $w = kl^3$ without serious inaccuracy, since in the expansion the errors would attain considerable dimensions. Some more approximate expression must be obtained. Now, in seeking for a function to represent the variation of weight with length in the case of a catch of fish such as plaice, we must find one such that

$$\int_b^a f(x)\ dx$$

should approximate as closely as possible to the sum of the average weights. If we integrate kl^3 for the limits of length representated, we will seldom find that such an approximation can be obtained.

The example given in the table on p. 224 illustrates this. The catch of fish has been sorted into 1 cm. groups and the averages of the weights of the fish in each group have been calculated and summed—it is 4,789 grams. The co-efficient k deduced as above explained is 1·01 and

$$\int_{16}^{37} 0{\cdot}0101\ l^3\ dl = 4565.$$

so that the difference is quite in the wrong direction. Some more approximate function must be obtained.

If we plot the logarithms of the lengths and average weights, a "mean straight line" can very easily and accurately be drawn among the points. We thus get the linear analogue of the parabola al^n.

$$\log w = \log a + n \log l$$

and from this the index n and the co-efficient a can be obtained graphically;* or the average weights may be fitted to the equation

$$w = a + bx + cx^2 + dx^3 +$$

by Pearson's method.†

However obvious it may appear that the weight should vary as the cube of the length, this is by no means necessarily the case. In the case of the catch represented by the table, the index of l is 3·227 and the co-efficient a (or k) is 0·005. The integral

$$\int_{16}^{37} 0{\cdot}005\ l^{3{\cdot}227}\ dl$$

is 5163. Further, it will be seen from the table that the average weights obtained by the equation $w = 0{\cdot}005\ l^{3{\cdot}227}$

* The method is described very clearly by R. Howard Duncan in "Practical Curve Tracing," Longmans, 1910.

† *Biometrika*, Vol. II. Palin Elderton, *op. cit.*, p. 30.

fit the original observations much better than do those calculated from $w = k\ l^3$; and if the two curves be plotted together it will be seen that the difference is too great to admit of the latter equation being used for calculations requiring accuracy of result.

A catch of 134 plaice from Beaumaris Bay, 13th July, 1910.

Mean Length (x)	Average Weight (y)	$y = kx^3$	$y=0{\cdot}005x^{3{\cdot}227}$
16·5	45·5	45·3	41·6
17·5	50·2	54·1	50·3
18·5	61·7	63·9	60·1
19·5	68·3	74·9	71·2
20·5	84·1	87·0	83·7
21·5	97·0	100·3	97·6
22·5	115·4	115·0	112·2
23·5	130·0	131·0	124·9
24·5	147·3	148·5	148·6
25·5	183·7	167·4	169·0
26·5	194·2	187·9	191·3
27·5	209·3	210·0	215·6
28·5	229·8	233·8	241·8
29·5	267·9	259·3	270·3
30·5	295·0	286·5	300·8
31·5	345·0	315·7	333·8
32·5	358·0	346·7	369·1
33·5	407·2	379·7	407·0
34·5	467·0	414·7	447·4
35·5	503·0	451·8	490·5
36·5	529·0	491·1	536·5
Total	4,788	4,565	4,763

GENERAL SUMMARY OF THE RESULTS OF THE PLAICE-MARKING EXPERIMENTS CARRIED OUT DURING THE YEARS 1904-1910.

By James Johnstone.

1. INTRODUCTION AND METHODS.

Experiments in marking and liberating living plaice were commenced in 1904 and were continued until the beginning of the year 1908; when, for various reasons, the investigations were discontinued. Short reports on the results of the separate experiments have been published in previous years,* but these have necessarily been incomplete since they dealt with data which were subsequently supplemented. Since no experiments have been made during the years 1909 and 1910, it is probable that no more marked fishes liberated during the period covered by the experiments will be recaptured. I propose, therefore, to give a short general summary of the results obtained from these four years' experiments, and to deduce such conclusions as appear to be probable ones, and which may possibly assist in the elaboration of further experiments.

The methods adopted were those in use by the English workers participating in the International Fishery Investigations. The mark consisted of a hard

* "Ann. Repts. Lancashire Sea-Fish. Laby." for the years 1904 to 1908, Liverpool, 1905-1909.

brass label, elliptical in shape, and measuring 16 × 11 mm. It was moulded so as to present convex and concave faces. A small hole was punched through the centre, and the concave face of the label bore the letters L, or LL, or LA, and the numbers 1 to 1,000. The silver wire used was 0·8 mm. in diameter. It was cut in lengths of 1 inch, and each piece had a loop of 1·5 mm. at one end, the loop being bent at right angles to the length of the wire. The bone buttons used were 16 mm. in diameter, flat on one side and convex on the other. Each had a hole drilled through the centre, and a small recess on the convex side to receive the loop of the wire. Each wire was, previously to making the experiment, threaded on a button, and arranged in a tray. A number of brass labels were threaded on a piece of wire.

Three workers were required for the experiment. One measured the fish and handed them to the operator; another noted the length of the fish and the number of the label, and then handed the latter to the operator. The fish was pierced through the fleshy part of the body by a steel needle, about half-way between the head and tail and about 1 cm. below the base of the dorsal fin, and the wire, bearing the bone button at one end, was then pushed through the fish, when the label was put on and another small loop made by means of round-nosed pliers and turned down on the label. The latter was on the ocular side of the body of the fish. Working in this way it is easy to mark 50 fish in less than half an hour. After seeing many examples of fish marked by other methods, I am convinced that the one described above is the best hitherto suggested.

It was generally necessary to make the experiments as quickly as possible so that the time of the vessel might be economised. The fish were therefore trawled only when they were abundant. Small experiments were made—10 to 75 fish as a rule—and the marked fish were at once liberated. Occasionally the fish had to be marked on a passage from the fishing ground to some other place, and it happens therefore that they were not always liberated on the ground where they were captured: I have mentioned the experiments where this was the case. Later on much larger experiments were made, and from 100 to 150 plaice were marked on the same day, the vessel "standing by" the fishing ground till the fish were liberated. On two occasions the fish were caught in stake nets and taken alive to the laboratory at Piel. They were then marked, and after remaining for some hours in the tanks were taken out to sea and liberated in the neighbourhood of the place of capture. When the fish were trawled a beam trawl of 30 feet beam, and with a net of 6-inch mesh, was used, and short hauls—$\frac{3}{4}$ to 1 hour—were made. In all future work it will be advisable to make large experiments, and to liberate at least 250 fish in the course of each. The other procedure need not, however, be different from that described above.

Some defects inherent in the methods adopted may be mentioned, and some criticisms noted. The brass label and the bone button are both liable to corrosion; the former because of electrolytic action, the brass being electro-negative to the silver wire, and the latter apparently because of the solvent action of the CO_2 in the sea-water. The result of this is that after about two years the numbers on the brass label *may* become illegible; while the hole in the bone button may enlarge so that the latter drops over the looped wire. The wire and label may then work their way out from the wound.

These defects may be remedied by using a silver label and a silver disc in place of the button, and such a modified mark may be recommended to those who are anxious to avoid all possible sources of error in method.

The amount of inconvenience or actual injury to the health of the fish caused by the attachment of the mark has probably been over-estimated in criticisms of the methods. It is very seldom that I have seen an enlarged and "sore" wound when the above method of marking was adopted; and I have never seen any indications of septic infection—a result that might have been anticipated. It has been suggested that the attachment of the mark *may* cause the fish to behave abnormally; to migrate along unusual paths; or perhaps retard the development of the reproductive organs, or inhibit the growth of the fish. I do not know on what experience these effects have been apprehended; certainly I have seen nothing that would lead one to expect that they would occur. It is quite probable that a certain proportion of the fish marked die after liberation, but this is because they have been injured in the trawl net. In a good experiment from one-quarter to one-half of the total number of fishes liberated are returned, and when one considers that many marked fishes are re-captured but not returned, while others are doubtless destroyed by their natural enemies, it is apparent that the marking operation is not prejudicial to the health of the fish. Further, a fair proportion of marked fish are returned after having been at large for a period of one to three years, and these have usually become mature, a fact which does not indicate that the mark is harmful to the fish.

It has been urged that marked fish may be liberated and then recaptured before they have had time to distribute themselves over a fairly large tract of sea bottom. I think this must happen very seldom indeed; should it happen, such exceptional captures would surely not be considered as indicative of other than an exceptional density of marked fishes apart from unmarked ones. But it must almost always be the case that a number of marked (or unmarked) fish liberated on a certain spot distribute themselves very rapidly and uniformly over all the tract of sea-bottom inhabited by the population of which they formed a sample. I have seen no indications that marked plaice, when liberated, segregate themselves, or distribute themselves in a different manner from that in which the population from which they were taken behaved; and it is incumbent on anyone who advances such a criticism to give instances where this has occurred, or to show *à priori* that it is likely to happen. Experiment 4 of 1907* dealt with 120 marked plaice, which were liberated between Great Ormes Head and Point Lynus in October of 1907. In November of that year a very intense fishery began in the same area, and lasted for two months, and on some days from 20 to 30 smacks trawled there. Yet only about 30 of these plaice were returned to me, and I regard this small proportion of recapture as indicative of a wide distribution of the marked fish over the whole area exploited. Let anyone who urges this segregation of marked fish as an objection to the results deduced mark some 100 plaice, and then, immediately after liberating them, attempt to trawl them up again. I should be greatly surprised if he succeeded in getting back even a small proportion after several days of fishing.

* "Ann. Rept. Lancashire Sea-Fish. Laby." for 1907, Liverpool, 1908, p. 39, Pl. II.

Experience of the investigations made in the Irish Sea during the last half-dozen years seems to show that the general methods involved in fish-marking experiments are sound enough. The only practicable improvement in method suggested by the results summarised in this report is the adoption of a few—four to six—large experiments in the year, instead of, say, twelve to twenty small ones. Further, the study of some preliminary experiments in any area of sea will indicate what should be the seasons for the experiments, and the places of liberation: obviously these will depend on the natural distribution of plaice in the area, and the incidence of the fishery seasons. It is now obvious enough when and where plaice should be marked and liberated so far as the Irish Sea on the eastern side is concerned.

2. STATIONS.

When the experiments were begun in 1904, they had to be made in such a way so as not to interfere with the other (and primary) duties of the steamer employed. Therefore a number of small experiments were made at convenient times. But it is clear, on considering the results, that not much is to be learned from the results of marking 30 to 50 plaice. Latterly large experiments were made, the opportunities for investigation of this nature having become more frequent. Meanwhile I propose to group together a number of the smaller experiments, considering each group as a unit. In making these groupings one is guided by a knowledge of the natural conditions of the fisheries on the eastern side of the Irish Sea.

The sketch-chart on p. 257 shows the general distribution of the marked fish recaught and returned.

Each spot indicates the approximate place where a fish has been recaught, and only those records which appear to have been above suspicion of error have been included. The chart is interesting, for it gives a graphic representation of the distribution of plaice in this part of the sea, which cannot be deduced from any series of statistics, "commercial" or otherwise, hitherto published: parenthetically, one may remark that a far more probable picture of the distribution, density and migrations of any one species of edible fish, such as the plaice, is to be obtained from the results of such "purely scientific" experiments as these, combined with the statistical examination of actual catches made by an exploring vessel under ordered conditions, than can be obtained from any system of statistical collection of data at the ports of landing. Obviously it is only such knowledge of the distribution, density and migrations of a species that can be of value for fishery administration; a knowledge of the quantities of fish landed at the ports helps us very little.

It will be seen from the chart that plaice are caught (in the eastern half of the Irish Sea) almost entirely within the 20-fathom line. In addition to the fishery which is carried on at most parts of the coast, but particularly in the bays and estuaries, by stake nets and second class sailing boats, there is an off-shore fishery which is concentrated to some extent on three roughly defined areas:—

(1) In the part of the sea South from parallel 54° N., and North-East from a line joining the estuary of the Dee and the South end of the Isle of Man. Plaice are trawled for over most of the sea-bottom inside this area, and between the land and the 20-fathom line. There is a curious vacant area opposite Blackpool and at the

immediate mouth of Morecambe Bay, where from which no marked plaice have been returned, and where little trawling is carried on. Immediately to the West of the line joining the Dee and Calf of Man, there also are few recaptures. The fishery in this area, which may be called the "Liverpool Bay off-shore area," is mostly a summer and autumn one, and the largest catches are made in the months June to October. Plaice are, of course, caught all through the year in this area, but the fishery is distinctively a summer and autumn one.

(2) A second plaice fishery area is that part of the sea North from the coasts of Anglesey and North Wales, both close in-shore and off-shore as far as the 20-fathom contour line. Occasionally the fishery is abundant as far East as the sea off Colwyn, but it is chiefly round Great Ormes Head in Carnarvonshire, in and off Red Wharf Bay out to the 20-fathom line, and in "Channel Course" (the track of vessels approaching Liverpool from Point Lynus in Anglesey), that plaice are very abundant. The fishery is a "back-end" one, beginning about October or November, and ceasing usually in January and February. We may call this the "Red Wharf Bay area."

(3) The third important plaice fishery area is that part of the sea East from the Isle of Man, and bounded on the South by the 54th parallel, and on the North by a line drawn from the North end of the Isle of Man to St. Bees Head in Cumberland. The fish are caught in greatest abundance in the vicinity of the banks extending from Ramsey Bay to the East. This fishery is a winter one, beginning about the end of the year and terminating in the early spring.

The only other area to be considered is that in Luce Bay, on the South coast of Scotland. It is of very great interest, since it is a plaice fishing ground in which trawling is prohibited by statute. It is in the area administered by the Fishery Board for Scotland, but we have been allowed to trawl there for experimental purposes, and a series of plaice-marking experiments have therefore been made.

Considering, then, this distribution of the plaice fishery areas, one feels justified in grouping together the various marking experiments as follows:—

(1) "Luce Bay." Five experiments have been made, all in the months October and November.

(2) "Morecambe Bay." A number of experiments have been made with fish caught off the mouth of Barrow Channel, and near Fleetwood, and these plaice have, as a rule, been liberated in Morecambe Bay or just outside the latter. The symmetry of the series is spoiled by three experiments: 10-'05 and 11-'05 relate to fish which were captured in the waters of Morecambe Bay, but which were liberated to the West of Morecambe Bay Light Ship, well off-shore. I have not hesitated to group these two experiments with others, and to regard them as "Morecambe Bay" ones for the following reasons:—Of the 74 plaice set free in experiment 10-'05 practically all must have returned into the Bay for an unusually large proportion were recaptured immediately after liberation in Barrow Channel and other parts of Morecambe Bay. Experiment 11-'05 dealt with a small number of fish, and very few were recaught, the fish being in very bad condition when liberated. In experiment 5-'06 plaice caught in the rivers Lune and Wyre were set free near Blackpool. The results of the "Morecambe Bay" experiments may be regarded as indicative of the movements of plaice from out of this area into other parts of the Irish Sea.

(3) "Liverpool Bay." This group consists of two series of experiments—fish liberated during the "winter" months, and fish liberated during the "summer" months. The area of liberation includes the sea from just off the mouth of the estuary of the Dee to off Blackpool. The fish were set free within the limits of the territorial area. Here again the symmetry of the winter experiments is marred by the fact that most of the fish set free were caught outside the area of liberation, some being caught in Red Wharf Bay, and others in the estuary of the Lune (in Morecambe Bay). But we will see that the winter migration is an along-shore one in either direction, so the results do not apply particularly to any one place. The summer experiments relate to fish caught and liberated in the same area, with two exceptions—experiments 15-'05 and 14-'05. But the former (in which the fish were set free off-shore) included only 19 fish, and the latter (which relates to fish captured in Beaumaris Bay) may perhaps be grouped together with the truly Liverpool Bay experiments, for the small number of fish set free in the former experiment does not affect the general results; while we are not comparing the migrations of plaice from the Red Wharf Bay area in the summer with other area-migrations.

(4) "Red Wharf Bay." Most of the fish dealt with were captured and liberated on the area as defined above. The only exception is experiment 4-'06, which relates to fish caught near Bahama Bank and taken across to the North Welsh coast. But only 8 plaice were so dealt with, and the results of the experiment can hardly affect the general results of the group. All the fish were liberated during the months October to February.

(5) "Bahama Bank." Only 65 plaice were

liberated in this area, and the results of the migration of this can hardly be considered. The interest of the area is that it is one which is inhabited by a considerable proportion of spawning plaice. One is more concerned with the question of where the plaice found on it come from, and we will see that it is possible to answer this question.

The sketch-charts on pp. 258-262 show the approximate positions of the places of liberation of the marked plaice. The lines enclosing coastal sea areas indicate approximately the areas of liberation formed by grouping the various experiments.

The table on p. 236 gives a summary of the results of the experiments.

3. RESULTS WITH RESPECT TO MIGRATIONS.

We may now consider the general results of these grouped experiments.

1. Luce Bay.

The plaice marked and liberated are, for the most part, immature fish captured while trawling for mature plaice for the Piel Hatchery. During the months of October and November, 1904 to 1908, five experiments were made and 241 fish in all were dealt with. Only 42 of these, or 17 per cent., have been returned, a small proportion, but not surprisingly so when we remember that trawling is entirely prohibited in Luce Bay and in the Clyde.

The recaptures, which are unrepresented in the charts, fall into three main groups: (1) 21 fishes caught in Luce Bay, mainly by means of set nets of about 8-inch mesh; (2) 9 fish recaught on the Bahama and King William Bank area, all during the months January-March; and (3) 7 fish recaught in the Firth of Clyde (one off Dhu Hearteach, West coast of Scotland). Two plaice were also recaught off the West coast of Ireland, and two in the Solway.

Plaice-marking Experiments, 1904-8.
Summary of Results.

Area.	Nos. of individual experiments.	Season.	Nos. of fishes marked.	Nos. re-captured.	Percentage re-captured.
Luce Bay	1-04, 7-04, 21-05 18-06, 2-08	Winter	241	42	17
Bahama Bank	2-04, 3-06	Winter	44	10	23
do.	16-05	Summer	21	2	10
Morecambe Bay	10-05, 11-05, 2-06, 5-06, 8-06, 1-08	Winter	395	136	34
Liverpool Bay	5-04, 6-04, 8-05, 22-05	Winter	223	98	44
do.	14-05, 15-05, 17-05 10-06, 15-06, 3-07	Summer	322	117	36
Beaumaris Bay	3-04, 4-04, 1-06, 4-06, 6-06, 1-07, 4-07	Winter	378	144	38
do.	17-06	Summer	41	15	37
Carnarvon Bay	9-05	Winter	50	12	24
Cardigan Bay	13-05, 18-05, 19-05, 20-05, 11-06, 12-06, 13-06, 14-06, 16-06	Summer	229	33	14
"Hatchery Experiments"	12-05, 7-06, 2-07	—	62	2	3
		Totals	2,006	611	30·4

The average length of the fish recaptured in Luce Bay was 29·3 cms.; in the Firth of Clyde, 35·3 cms.; and on the Bahama-King William Bank area, 31 cms. The two fish recaught in the Solway measured 20 cms.; those off the West coast of Ireland 32 and 39 cms.

In interpreting these facts two things are noticeable: (1) No plaice marked and liberated in the Irish

Sea have been known to migrate into Luce Bay, though it is an opinion often expressed by experienced fishermen that they do so; (2) the migrations out from the Bay appear to be chiefly those of fish which go to the Bahama Bank area, probably to spawn there. The conclusions deducible at this stage are: (1) Luce Bay is inhabited by a plaice population of nearly all ages, and since it is closed against trawling in every form, the larger fish are present in greater proportion than in the more intensely fished plaice grounds in the Irish Sea; (2) it is a natural "nursery" from which plaice approaching sexual maturity emigrate in order to spawn, and they do spawn on the fishing grounds off Bahama Bank and in the Firth of Clyde; (3) Luce Bay is populated by plaice which have, in their youngest phases of life, inhabited the Solway Firth, or from larvæ spawned on the grounds between Isle of Man and Cumberland.

2. **Morecambe Bay.** Chart II, p. 258.

This series includes a group of experiments made during the months February to May in the years 1905-6-8. The numbers of the separate experiments are given in the table on p. 236 and I have already discussed the propriety of the grouping. The approximate positions of recapture are indicated on the chart, and the latter shows the main migrations so clearly that only a few explanatory remarks are necessary. Some records of marked fishes returned are omitted in this (and the other) charts because the information sent with the fishes was incomplete or doubtful. We see that the recaptures fall into three main groups: (1) plaice caught in the in-shore waters of Morecambe Bay, and along the coast further South as far as Holyhead Harbour; (2) plaice caught on the "Liverpool Bay" fishing grounds; and (3) plaice caught on the "Bahama Bank" area. In addition, three fishes have been recaught outside the Irish Sea. The lengths of the fishes caught in these three groups differ significantly. (1) Those taken in the Bay and along the coast have a modal length of 23 centimetres: they have been taken inside the five-fathom line; (2) the mean length of the plaice caught on the "Liverpool Bay" fishing grounds is 26·5 cms.: they were mostly taken between the 10 and 20-fathom lines; (3) the mean length of the fish taken on the "Bahama Bank" area is 29 cms.: they were caught just outside the 10-fathom line. Thus there is a progressive increase in mean length of the fish taken in order of the three areas.

The season of recapture also varies progressively: (1) The fish recaptured in Morecambe Bay and along the coast line were taken almost all in April-May; (2) those recaught in the "Liverpool Bay" area were caught during the months June to September; and (3) those recaught on the Bahama Bank area were mostly caught during the months October to March.

These facts can be put together to form a fairly probable picture of the movements of plaice with respect to the Morecambe Bay area. The small plaice caught there are those that inhabit the in-shore waters in their earlier stages. They originate from the eggs and larvæ drifted in from the off-shore spawning areas, and the fish remain on the shallow water grounds until they reach a length of about 20 cms. Migration then begins, and plaice measuring about 20 to 27 cms. shoal on the feeding grounds just off the land in the spring of the year. About the middle of the year fairly large catches of plaice, a little larger than those just mentioned, may be made in the channels just off-shore: the fish are now migrating out into deeper water, and it is partly these fish which go to populate the "Liverpool Bay" area. Later in the year this population becomes thinned out, partly by the intense trawling, but also by emigration to more off-shore grounds, and so we find that the larger of the plaice liberated in the shallow Morecambe Bay waters finally reach the grounds to the North-East of Isle of Man. The first migration from the Bay to the off-shore waters of the "Liverpool Bay" area is a "feeding migration"; the latter movement to the North is a "spawning migration," and it is principally on the "Bahama Bank" area that sexually mature plaice are to be found in the eastern side of the Irish Sea.

3. **Liverpool Bay.** Charts III and IV.

Two groups of experiments are considered. The summer experiments were made during the months of June and July, 1905-6-7, and the greater number of the plaice marked were caught and liberated near the "Nelson Buoy," off the estuary of the Ribble (but see p. 233). In all 322 fishes were marked, and of these 117, or 36 per cent., have been traced. The chart shows that most of the fishes recaptured had migrated off-shore into the "Liverpool Bay" area. The migration paths during the summer months are not extensive ones, but there is a general trend of the fish to the West and North. The modal length of these summer-caught plaice was about 24·5 cms. There are two principal winter migrations: (1) alongshore, most of the fish remaining in relatively shallow water: the mean length of these winter-caught plaice is 26·5 cms., the difference between this length and that of the summer-caught fish being about that due to the longer period of growth; (2) the northerly winter migration to the "Bahama Bank" area. The mean length of the few fishes making this latter migration is 28 cms., so that there is a distinct segregation of the plaice, the smaller ones remaining in the in-shore waters and the larger ones beginning the off-shore spawning movement.

A number of the plaice liberated have also migrated to the South into St. George's Channel, but these may best be considered later on.

The migrations of the fish liberated during the winter months differ notably from those made by the summer-liberated fish. They are represented on Chart IV. There are two principal migration paths (1) along the coast in an indifferent direction, the fish seeking the shallower waters just off-shore, and (2) the migration North to the "Bahama Bank" area. Here again we see the segregation according to size, for the modal length of the plaice recaught on the shallow water grounds is only about 22 cms., while the mean length of the fish recaught on the Bahama Bank area is 29 cms. Many of these winter-liberated fish have been recaught during the following summer, and these for the most part have performed the characteristic off-shore migration into the deeper waters of Liverpool Bay. Some have migrated into the Red Wharf Bay area, but one must not regard this as a likely summer migration path from the Liverpool Bay area, for some of the fish liberated in the latter area were brought from Red Wharf Bay, and at any rate the summer-caught fish may be only those which have moved into the Red Wharf Bay grounds during the previous winter.

4. **Red Wharf Bay.** Chart V.

All the experiments made in this area were winter ones with one exception, 17-'06. I do not propose to consider this experiment: it was a small one, and most of the fish returned were caught within the area of liberation. The winter experiments include 378 plaice, and of these 144, or 38 per cent. have been returned. With the exception of 8 fish caught near Bahama Bank, all the plaice marked were caught in the area where they were set free. One experiment was spoiled by the use of aluminium labels: in contact with silver this metal is rapidly corroded in sea-water, and very few of the fishes so marked have been traced.

The chart shows clearly that plaice set free in the "Red Wharf Bay" area in the winter months tend to remain there for some time; thus most of the recaptures were made during the month or two immediately after the date of liberation. The modal length of these plaice is about 25·5 cms. Considering now the emigrations from the area of liberation, we find just what has been seen to be the case with the plaice set free in the "Liverpool Bay" area, viz., (1) a winter emigration along the shore both to the East and South; (2) a winter emigration to the spawning grounds near the "Bahama Bank" area: the mean length of the few plaice making this movement is about 29 cms.; and (3) a well marked summer migration to the off-shore grounds in "Liverpool Bay": the mean length of the plaice so moving is about 26·5 cms. In addition to these movements there is a marked emigration of plaice from the Red Wharf Bay area to the South and West of Ireland, and to Cardigan and Carnarvon Bays. This latter movement may be considered separately.

5. **Other Experiments.**

So far, the numbers of plaice liberated have been large enough to enable one to determine, with some degree of probability, the general movements of plaice in the eastern part of the Irish Sea. Other experiments made have either been too small to enable general results to be deduced, or they have been devised under conditions which did not render a successful result probable. Thus a few plaice were marked and set free during the winters of 1904 and 1906 on the Bahama Bank area, but the number was too small for results of value to emerge from the data. I do not discuss these here: the experiment is one which may profitably be repeated on a larger scale. Some flounders were marked and liberated, and though the results were encouraging, there are not enough data to discuss; here again the experiments ought to be repeated on a larger scale, for the flounder is a fish of some local value. Several brill were also marked, but not in large numbers. The fish is one which is favourable for the experimental methods, but it is not abundant enough to be marked on a large scale. Soles were also marked, but no success attended the experiment. The method used for plaice is quite unsuitable for this fish. Only one cod was marked, and it was not recovered. Both plaice and flounders which had been kept throughout the winter in the hatchery tanks at Piel and Port Erin were marked and liberated. Some of the flounders were recovered, and one or two plaice were also recovered, but it is obviously the case that fish which have been kept in captivity in tanks or small ponds for many months become so enfeebled that they do not survive the marking operation and the subsequent transportation. Of 23 plaice taken from the Piel Hatchery and set free near Blackpool, only two were recovered; 11 fish were taken out to near the South end of Isle of Man, but none was recovered; 28 hatchery plaice were marked and liberated at Port Erin, but again none was returned.

Some experiments were made in Carnarvon and Cardigan Bays, dealing in all with 291 plaice. This number is too small when one remembers that there is far less trawling in this part of the Lancashire and Western District than there is North of Holyhead. In order to obtain evidence of strictly local migrations, many more plaice than the number mentioned would have to be marked. The experiments are, however, interesting from the point of view of the larger migrations, and they may be considered with this in mind.

6. **Migrations out from the Irish Sea.** Chart VI.

In considering the larger migrations, one may as well regard all the territorial waters extending from Anglesey to North from Morecambe Bay as one area, and regard the various experiments made during the years 1904-8 as forming one experiment; while the various small experiments made in Carnarvon and Cardigan Bays may also be grouped together. Now, looking at the results from this broad standpoint, some interesting conclusions emerge from the data:—

(1) There is a well marked tendency for the larger fish set free in the territorial waters North from Anglesey to emigrate to the West and South, recaptures being recorded from a number of places on the East coast of Ireland, from the entrance to St. George's Channel, and from the Bristol Channel. At least 36 fish have been so traced, excluding some doubtful records. Either the larger fish set free off the coast of Lancashire and North

Wales at once emigrate to the South and West, or they begin so to move when they attain a certain size. This migration is a spawning one, for a fair proportion of the fish returned were sexually mature. Considering all the fish with regard to which full information is available, we find that the curve of length-frequency shows two modes, at 29 and 37 cms. The range of length is therefore that of mature fish, and the probable conclusion is that plaice reared off the coasts of Lancashire and North Wales migrate either to the South and West of St. George's Channel in order to spawn, or they migrate to the "Bahama Bank" area off the North-East of Isle of Man for the same purpose. It is difficult to say yet which migration path predominates, but it is probable that it is the former one.

(2) Plaice marked and liberated in Cardigan and Carnarvon Bays behave similarly with respect to these longer migrations, moving either towards the East coast of Ireland or the Bristol Channel. Thus the mean length of the fish liberated there and recaptured *in situ* is 26 cms., while that of the plaice which have emigrated out from these Bays to the West and South is 30·5 cms. The mean length of the plaice originally set free in the Welsh bays, and which have been recovered from off the coast North from Anglesey, is 24·5 cms. Thus there is a segregation of the fish with respect to their sizes and their migration paths. There is no record of a plaice liberated in the Welsh bays migrating to the Bahama Bank area.

(3) Migrations of plaice from the eastern part of the Irish Sea to either the North (Firth of Clyde and Solway and Isle of Man), to the East and South-East coasts of Ireland, and to the mouth of St. George's Channel and the Bristol Channel, are therefore numerous enough in

the results of these experiments to enable us to conclude that such migrations of the larger plaice inhabiting our area do naturally take place on a large scale. In fact, one may probably conclude with some degree of certainty that the small plaice population in the eastern side of the Irish Sea originates from the larvæ spawned to the South in St. George's Channel and transported to the North-East round the coast of Anglesey with the Gulf Stream drift, which, as Dr. Bassett* has shown, gradually increases in strength during the spring of the year, at such a time when the plaice are probably spawning. But the contrary migration is a rare one, that is, few plaice migrate from the East coast of Ireland over to the West coast of England, and few migrate from the Welsh bays round Holyhead to the coasts of Lancashire and North Wales. None of the plaice marked and liberated by the Irish Department of Agriculture and Technical Instruction on the East coast of Ireland has yet been traced to the English side of the Irish Sea, and of the 229 plaice liberated in Carnarvon and Cardigan Bays only five have been recovered from the sea North-East from Anglesey.

(4) One further regularity may be mentioned. The "Morecambe Bay" grouped experiments include 395 fish, and less than one per cent. of these have undergone the migration to the South and West round Anglesey or across the Channel. The "Liverpool Bay" experiments include 545 fish, and about $2\frac{1}{2}$ per cent. of these have made the same migration. Finally, the "Red Wharf Bay" experiments, including some 420 fish, have been the most fruitful in this respect, for rather over 5 per cent. of them have migrated to the East and South. But one must remember that the modal length

* "Ann. Rept. Lancashire Sea-Fish. Laby. for 1909," p. 148.

of the plaice taken in the Red Wharf Bay area is significantly greater than that characterising the fish of the other two areas, and that since the migrations in question are spawning ones, it is likely that the larger fish would participate in it to a greater extent than the others.

7. Intensity of Fishing.

One may be expected to discuss the question of whether or not the relative intensity of fishing can be deduced from the relative proportion of recaptures in different areas, during the same period of time. Now no one with experience of fishery investigation is likely to claim that the amount of fishing is exactly in proportion to the percentages of marked fish recaught; but, given that the same care is always observed in catching, sorting and marking the fish, and that the same investigators have carried out the experiments compared, then it seems to me that *some* degree of correlation must exist between the relative intensity of fishing and the relative percentages of recaptures given good fishery statistics and it should be possible to express this correlation numerically. If, again, anyone with experience of the local fisheries examines such a chart as I, p. 257, he will notice that it is just where the trawling and stake-netting are most extensively carried on that there are most recaptures. If his attention were drawn to the paucity of recaptures in certain regions, he will probably say that this is because little trawling is carried on there. And this is equivalent to asserting that there is correspondence between intensity of fishing and percentage of recaptures.

4. GROWTH-RATE OF PLAICE IN THE IRISH SEA AND ST. GEORGE'S CHANNEL.

We may deduce two things from the data obtained by comparing the lengths of the marked plaice when liberated with the lengths of the same fishes when recaptured: (1) the growth from month to month throughout the year, and (2) the growth per year. These observations relate to plaice of the range of lengths dealt with in the experiments, and this was about 8 to 11 inches. It is very unlikely that the growth rate of a plaice of 8 inches during the next three years of life will differ greatly from that of a fish of 11 inches. At any rate, what we are concerned with here is to obtain a mean expression of the growth rate of the plaice usually caught in the course of commercial trawling in West coast in-shore waters.

It is very much easier to find defects in the methods employed in this investigation than to devise experiments which will be free from error; and one may remark in passing that it is usually those who have not personally made marked fish experiments that are most ready to criticise such results as are here presented. Various sources of error are obvious enough:—

(1) The fish were initially measured to the nearest $\frac{1}{4}$ inch, but when recaptured they were measured to the nearest $\frac{1}{8}$ inch. If the method of measurement adopted in the International Fishery Investigations had been originally adopted, the initial mean length would have been $x\frac{1}{8}$, $x\frac{3}{8}$, etc., inches, with an error of $\pm\ \frac{1}{8}$ inch; as it is, the initial mean lengths are $x\frac{1}{4}$, $x\frac{1}{2}$, etc., with an error of $\pm\ \frac{1}{8}$ inch. The general result is that, in comparing these results with those obtained by investigators employing the International system of fish measurements, $\frac{1}{8}$ inch (or its metric equivalent) must be

added. The difference between the accuracy of measuring the fish when caught, and again when recaught, disappears when the data are treated statistically; though in the case of individual examples it might lead to such an anomalous result as a negative growth.

(2) The fish when dead *may* have contracted to a significant extent. I discuss this question on p. 187 of this Report, but as a rule, in measuring recaught marked plaice, the fish has been "stretched," a plan suggested by Mr. G. P. Farran. One holds the fish by the head and tail, and then pulls at it—not so strongly, of course, as to break it in two—and the fish slightly elongates. The increase in length is probably very nearly equivalent to the shortening produced when *rigor mortis* sets in.

The Amount of Yearly Growth.

If the increments in length of all the marked plaice recovered after one complete season's growth, and no more, be added together and divided by the number of cases, we obtain the mean annual growth for the range of lengths represented. The experiments undertaken in the Irish Sea give 58 such cases, and the mean annual growth increment is 2·836 inches, or 7·2 cms. The limits are 2·5 cms. and 13·3 cms.; the standard deviation is 8·78, and the probable error, $\frac{\sigma}{\sqrt{58}} = \pm\ 1{\cdot}14$ cms.

Cases of 10 marked plaice recovered after two complete seasons' growth, and no more, are represented in the results, and the mean increment is 5·53 inches, or 14·04 cms., very approximately double that of the single season's growth. Only one case of a plaice recovered after three complete seasons' growth is represented, and the increment is 9 inches, or 23 cms., very approximately three times that of a single season's growth. In the case of these fish which have undergone two or three seasons' growth, the number of cases is too small for the calculation of a probable error.

The Growth Rate from Month to Month.

A knowledge of the above is of some importance, and I have made an attempt to deduce it from the data at hand. In dealing with these data it has been assumed that there is no difference between the plaice caught from the various regions of the Irish Sea with respect to their growth rate. Since the plaice originally caught on any one local fishing ground may migrate into any other, one is justified in making this assumption and in treating the statistical material as homogeneous. It is further assumed that all plaice liberated after the end of September and before the beginning of April may be considered together as constituting the material of one experiment, that is to say, that the amount of growth during those months is so small that it may be neglected. There is, of course, some growth during the last three months of the year, and it is probable that this amount of growth may be variable from year to year—for the length-weight co-efficient k does not vary in this manner—but we may, without serious error, proceed on this assumption.

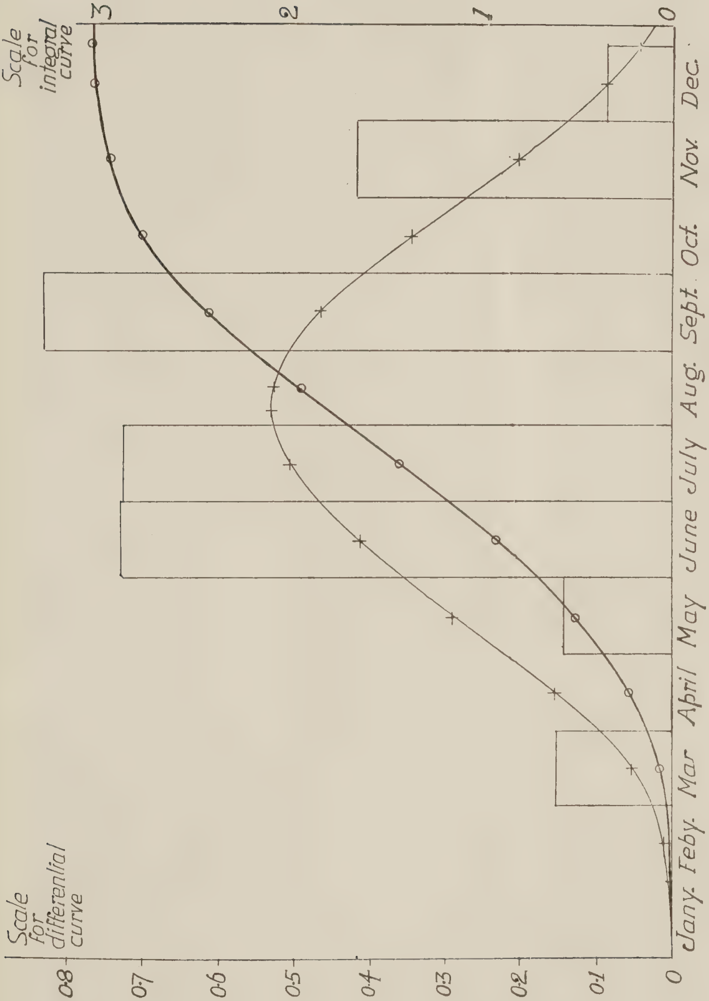
The following table gives the data and results of this estimation, and the method of calculation may briefly be described.

Growth Rate of Plaice throughout the year in the Irish Sea and St. George's Channel as deduced from Marking Experiments (1905-1910).

Month.	No. of fish measured. (1)	Total Increase in length (inches). (2)	Mean Increase in length (inches) (3)	Rate of Increase per month. (4)	Theoretical Rate of Increase per month. (5)	Cumulative growth from month to month. (6)
October	5	0·55	0·110	0·110		
November	21	1·25	0·060	−0·050		
December	46	8·375	0·180	0·120		
January	16	1·45	0·090	−0·090	0·0000	0·00007
February	19	1·00	0·052	−0·038	0·0090	0·00452
March	19	3·875	0·204	0·152	0·0546	0·06177
April	55	10·075	0·183	−0·021	0·1544	0·21770
May	43	14·0	0·325	0·142	0·2881	0·50577
June	23	24·125	1·049	0·724	0·4195	0·92346
July	23	40·875	1·772	0·723	0·5029	1·42478
August	27	43·80	1·622	−0·150	0·5224	1·94410
September	14	34·40	2·457	0·835	0·4613	2·40294
October	9	20·125	2·236	−0·221	0·3425	2·74467
November	14	37·125	2·651	0·415	0·2046	2·95026
December	19	52·025	2·737	0·086	0·0887	3·04112
	353			2·737	3·0480	

Column (3) is formed from column (2) by taking the means.
Column (4) is formed by taking differences from column (3).
The calculation of columns (5) and (6) is explained in the text.

Column (1) gives the numbers of plaice measured in each month during the years 1905-1910, and 353 fish in all are dealt with. These are fish which have been recovered during the Octobers, Novembers, etc., of the years in question, and which had been liberated during the season of minimal growth, October-March. Column (2) represents the *total* increase in length of *all* the fish recovered in each month, and column (3) gives the mean increment of growth of the mean fish between the beginning of the season of minimal growth and the middle of the month of recapture. Column (4) represents the *rate of increase* per month; the figures are obtained



Growth of plaice throughout the year in the Irish Sea. Thin line = rate of growth; thick line = integrated growth. The columns represent the actual growth rata observed.

by taking the difference between the mean increase in length of any one month and that of the preceding month.

It will be seen that the rate of increase for some months is negative—a somewhat paradoxical result. This appears particularly with regard to the month August, and when I first observed it I ascribed the result to the under-measurement of the marked fish recovered during the August of the year in question. But the same anomalous result was observed in other years, and in different experiments considered separately; and it has also been observed by Mr. Farran,* so that one must regard it as susceptible of some other explanation. It is obvious that we have to deal with a differential migration in or about those months when a negative increment of growth is observed; that is, the movements of the plaice are such that the more rapidly growing fish are migrating to grounds where they are not caught, or are caught in far fewer numbers. On the other hand, the more slowly growing plaice have remained on the grounds where the fishery was relatively intense. This is, indeed, a very probable explanation. There is no sense in a negative growth. The value in column (3) cannot be less than that of the preceding month, and if one were drawing a smoothed curve through the points given in the column, he would be justified in interpolating a value for the month exhibiting a negative growth. But the figures can be better dealt with otherwise.

The rates of increase given in column (4) have been considered as values lying about a probability curve, and have been dealt with by Pearson's method of

* "Plaice-Marking Experiments," *Fisheries, Ireland, Sci. Invest.*, 1907, III, [1909].

moments, but instead of the negative values of the months November, January, etc., zero values have been substituted. I am uncertain whether or not this is the correct practice. The statistical constants obtained in this way are as follows* (the values in column (4) have been multiplied by 1,000):—

$$d = 0{\cdot}6967826$$
$$\mu_2 = 4{\cdot}666915$$
$$\mu_3 = 0{\cdot}436612$$
$$\mu_4 = 54{\cdot}9096$$
$$\beta_1 = 0{\cdot}001875$$
$$\beta_2 = 2.52109$$
$$k = -0{\cdot}0014$$
$$m = 3{\cdot}764225$$
$$a = 7{\cdot}009664$$
$$y_0 = \frac{N \times \Gamma(2m+2)}{a\,2^{2m+1}\{\Gamma(m+1)\}^2} = 526{\cdot}64.$$

The mean = mode = origin is at 7·696782.

The curve is Pearson's Type II, or

$$y = y_0\left(1 - \frac{x^2}{a^2}\right)^m$$

and is symmetrical and limited in both directions (the start and finish being $-a$ and $+a$).

The figures in column (5) have been obtained by calculating ordinates from the above constants. The latter, or the latter two figures, have, of course, only an arithmetical significance.

Column (6) represents the values of column (3) smoothed, or graduated by the application of Pearson's method of calculating a most probable frequency curve

* The notation is that of Palin Elderston's "Frequency Curves and Correlation."

for a series of rough values. One could not have done this in any other way without introducing the undesirable tendency to make the curve go the way he wanted it. To arrive at the figures in column (6) the function $y_0\left(1 - \frac{x^2}{a^2}\right)^m$ has to be integrated, and the definite integrals representing the limits January-February, January-March, and so on, have to be evaluated. But this is so difficult as to be quite impracticable, and I have approximated to the integral curve by calculating ordinates for the beginning, middle, and end of each month, and then finding the area of the curve between the ordinates at the beginning and end of the month by means of Simpson's quadrature formula

$$\int_0^1 y\,dx = \frac{1}{6}\left(y_0 + 4\,y_{\frac{1}{2}} + y_1\right)$$

and hope this may be accurate enough for the purpose. The areas have then been summed, giving the figures of column (6).

Now, although the above is the most obvious way of obtaining regularity from very rough data, it is likely that it is not the best way. Professor D'Arcy W. Thompson has pointed out to me that, since the growth of a fish is to be represented by a cyclic curve—since it grows from year to year—a sine curve ought to be used. That this is true is indicated by the fact that constants representing Pearson's "Type II" frequency curve were obtained from the calculation, though obviously "Type VII"—the normal curve of error—should have applied, the range being infinite.

Marked Plaice recovered during the years 1909-1910.

No. of label.	No. of Experiment	Initial length (cms.)	Date of Recapture	Place of Recapture (Latitude) (Longitude)	Length when Recaptured (cms.).	Increase in length (cms.)
Illegible			9/5/10	53° 10′ N. 5° 45′ W.	40·2	
LL221	XI—1906	25	20/1/10	52° 18′ N. 6° 20′ W.	42·5	17·5
LL232	XI—1906	20	29/1/10	52° 45′ N. 4° 28′ W.	34·2	14·2
LL566	I—1907	22	23/12/09	53° 10′ N. 4° 15′ W.	45	23
LL618	I—1908	24	6/3/10	54° 2′ N. 3° 45′ W.	40	16
LL647	IV—1907	21	15/4/10	51° N. 4° 40′ W.	36·2	15·2
LL676	I—1907	21	6/1/09	53° 10′ N. 4° 15′ W.	33	12
LL682	III—1907	21	21/5/09	53° 18′ N. 5° 50′ W.	37·4	16·4
LL805	III—1907	21	26/1/09	53° 55′ N. 5° 50′ W.		
LL868	IV—1907	32	21/7/09	53° 30′ N. 5° 55′ W.	45·6	13·6
LL875	IV—1907	26	3/7/10	51° 50′ N. 5° 46′ W.	38·6	12·6
LL924	IV—1907	24	6/4/09	52° 45′ N. 4° 28′ W.	33	9
LL937	IV—1907	26	0/9/09	51° 36′ N. 6° 12′ W.	38	12
LA9	II—1908	32	28/7/09	54° 48′ N. 4° 55′ W.		
LA29	II—1908	35	21/2/09	54° 16′ N. 4° 1′ W.	35	0
LA46	II—1908	26	25/8/09		32	6

Explanation of the Charts.

The charts are all drawn to the same scale, and the spots or circles represent the approximate positions of recapture of the marked plaice recovered. Obviously these positions are only approximate, since in most cases it is not quite certain what was the precise position of the vessel when the fish in question was captured. Also the scale of the charts is so small that in the case of a great number of recaptures in a limited area it has been impossible to map the positions accurately for each fish taken. The charts do not include all the fish returned, since it was impossible to trace the position of recapture in many cases. In some instances the position has been estimated approximately from a knowledge of the probable movements of the vessels concerned.

Chart I.

This shows the approximate positions of all the marked plaice recorded, irrespective of the experiment. It is not intended to serve as a representation of the measure of intensity of fishing on the plaice grounds of the Irish Sea East from Isle of Man, though it will be noticed by anyone familiar with the fisheries in this area that the recaptures are most numerous just where the plaice fisheries are most intense—estimating the intensity of the fishery by other means than that of marked fish experiments. The recaptures in Carnarvon and Cardigan Bays are not charted, since the number of fish returned from this area is so small as to render the experiments there of little interest. The intensity of the plaice fishery here is much less than in the Irish Sea North-East from Anglesey.

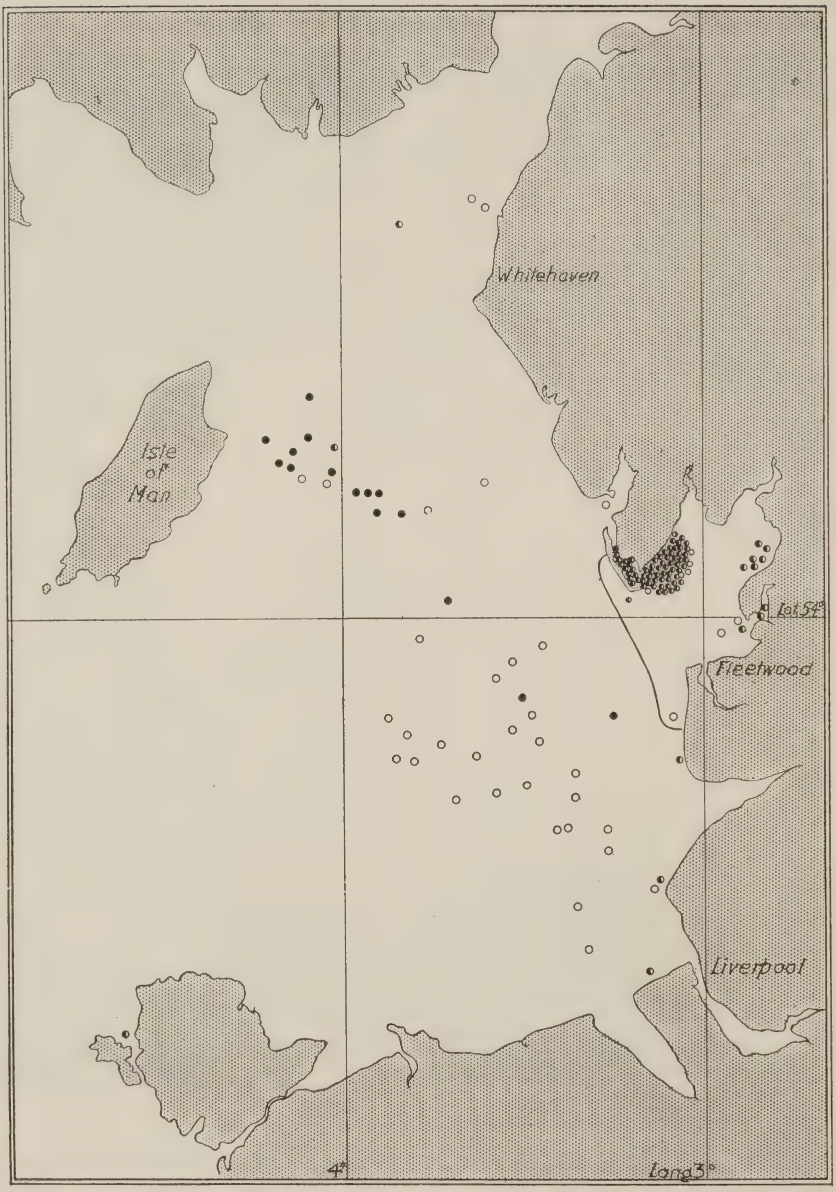
Charts II to VI.

These are explained in each case in the respective legend.

CHART I.

Approximate positions of recapture of most of the marked plaice recovered from the experiments of 1904-1908.

CHART II.



Recaptures of plaice liberated in or near Morecambe Bay—winter experiments excluded. Black dots represent fish recaptured in the winter months; circles fish recaught in the summer months; half shaded circles fish recaught in April and May. See p. 237.

Chart III.

Recaptures of plaice liberated in the Liverpool Bay Experiments (within the area represented by the line on the sea). Black dots represent fish recaught in the winter months; circles those recaught in the summer months. See p. 239.

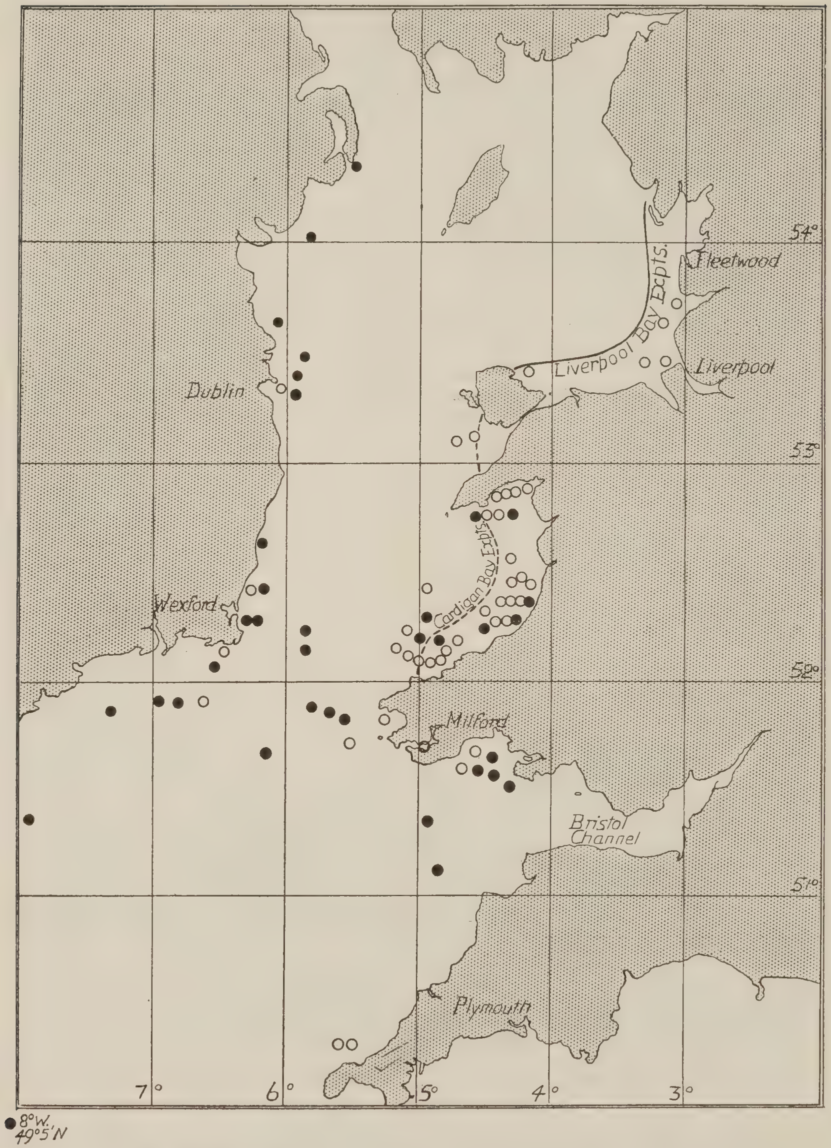
CHART IV.

Liverpool Bay winter experiments. The line on the sea marks the boundary of the area within which the fish were liberated; the black dots represent recaptures of fish during the winter months; the circles those of fish during the summer months. See p. 239.

CHART V.

Experiments made in the Red-Wharf Bay area in the winter months. Black dots represent recaptures in the winter months; circles those made in the summer months. See p. 241.

CHART VI.



Approximate positions of recapture of marked plaice which have made migrations from out the Liverpool Bay—Morecambe Bay area; and also results of the Carnarvon and Cardigan Bay experiments. Black dots represent recaptures of fish liberated in the Liverpool Bay area; circles those of fish liberated in Carnarvon and Cardigan Bays. See p. 243.

AN INTENSIVE STUDY OF THE MARINE PLANKTON AROUND THE SOUTH END OF THE ISLE OF MAN.—PART IV.

By W. A. Herdman, F.R.S., and Andrew Scott, A.L.S.

[Explanatory Note.—The work has been carried on during 1910 on the same general lines as in the previous three years. Professor Herdman has been responsible for collecting the material, partly in Port Erin Bay during the year and partly at sea from his yacht "Ladybird"; while Mr. Scott, at the Piel Laboratory, has examined in detail the preserved catches, and filled up the forms. This report has been drawn up at Liverpool by Professor Herdman, with the assistance of Miss H. M. Lewis, who has compiled the tables of statistics and plotted the curves. Mr. Wm. Riddell again gave most efficient help in the collecting operations at sea from the yacht, and both he and Mr. H. C. Chadwick took part in straining and preserving and measuring the catches at Port Erin.—W. A. H.]

INTRODUCTION.

For full details in regard to our methods we must refer to Part I of this series (in the Report for 1907); and for the discussion of some points which we consider it unnecessary to deal with further, reference must be made to one or other of the three preceding parts. In fact, although the general arrangement of the matter will be the same as in Part III, we shall now give in detail only what is new or what we require for comparison with the other years.

The Material Available.

We have fortunately again been able to make large collections, as we consider that in work of this kind it is only possible to arrive at sound and reliable conclusions when the data are derived from large series of samples. When the present collections are added to those of former years, we have now, as the total number of plankton-gatherings from a small area of the Irish Sea, over 2,500 samples, made up as follows:—

Year.	At sea, from yacht.		In Bay throughout year.	Totals.
	Spring.	Autumn.		
1907	218	279	138	635
1908	156	242	157	555
1909	329	147	231 + 49	756
1910	107	249	296	652
Totals ...	810	917	871	2,598

These are very substantial numbers, and they ought to yield reliable conclusions as to the seasonal variations in the plankton throughout the year, and as to the characters of individual years. It is unnecessary to repeat what we said last year (Part III, p. 195), as to the values to be attached to our different nets, and as to the comparability of our hauls one with another.

Outline of the Year's Work.

Throughout the year 1910, from January 3rd to December 30th inclusive, "official" gatherings were taken across Port Erin Bay, by the staff of the Biological Station, generally twice a week, and sometimes more frequently. On each such occasion two surface hauls were made, one with a coarse and the other with a fine net, and after January a third gathering, a vertical haul near the mouth of the bay, was also taken.

The S.Y. "Ladybird" was fitted out for the season towards the end of March, and her first plankton trip was on April 7th. From that date onwards to April 25th she was constantly engaged in this work, and obtained 107 gatherings on 13 working days. During April, then, we have the yacht's gatherings out at sea, and the "official" gatherings inside the bay, available for comparison. The same is true of the greater part of August and September, when the "Ladybird" again took plankton gatherings, from August 8th to September 17th inclusive (249 gatherings in 23 working days). For the rest of the year we have the "official" collections made in the bay.

Methods and Equipment.

In the main the methods of work were purposely the same as in the previous three years. The same localities at sea were visited (see map in last report), and the same series of nets were used—Hensen and Nansen vertical closing, surface and deeper horizontal nets with funnels, fine and coarse, two with otter boards, one on each side of the ship, and the large-meshed shear-net and yngel trawl. The Lucas sounding machine was found most useful, and the Ekman water-bottle, fitted with Richter reversing thermometers, was used in the deeper water.

An addition to the oceanographical equipment of the yacht made this year was V. W. Ekman's Current-meter, two views and an enlarged detail of which are given in fig. 1. It may be convenient for workers and

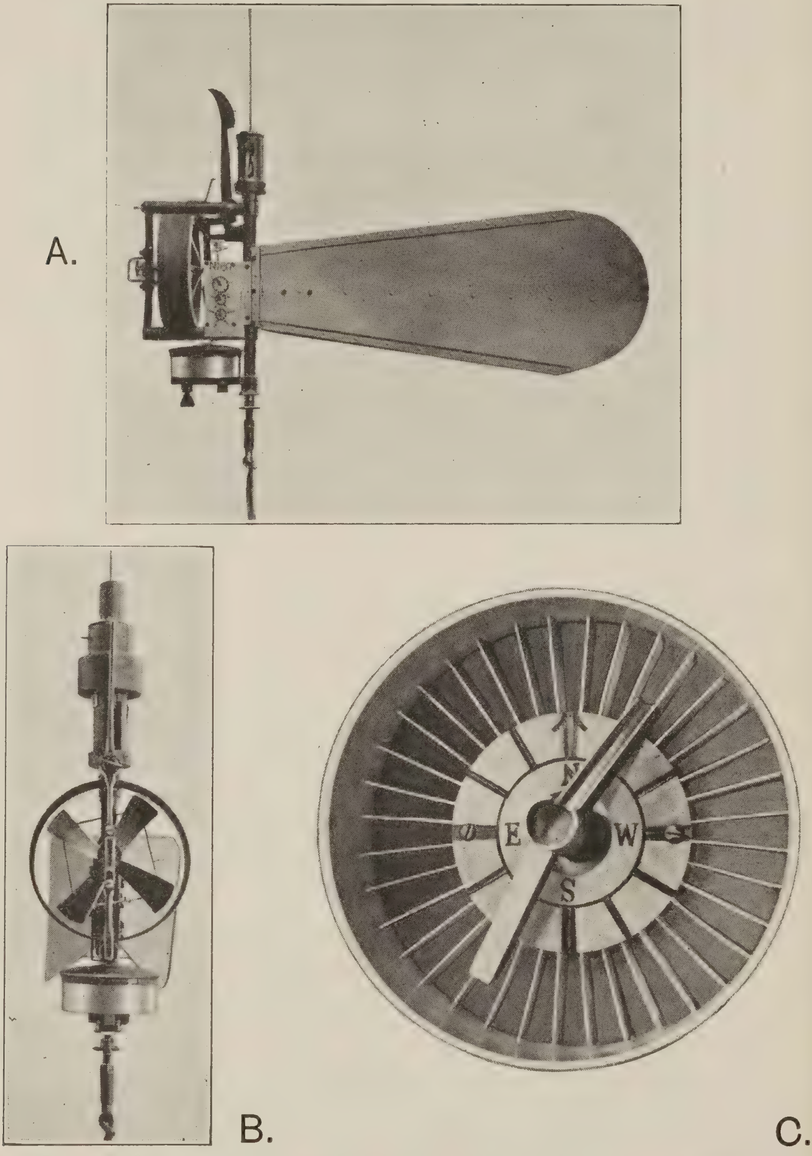


FIG. 1. The Ekman Propeller Current Meter ("Propell-Strommesser") in use on S.Y "Ladybird":—

A. Side view showing vane, dials, compass-box, releasing catch, &c.
B. End view showing propeller, &c Both messengers are in position.
C. Compass-box for receiving the brass pellets.

students in this country to have here the following brief account of this ingenious instrument.*

Ekman's "Propell-Strommesser" consists essentially of (1) a propeller with counting mechanism attached (A and B, fig. 1); (2) a vane (A, fig. 1), to keep the propeller always facing the current; and (3) a compass-box (C, fig. 1), by means of which the variations of direction in the current are measured. To prevent any movement of the propeller while the machine is being lowered to the required depth, the propeller is fastened by a catch (seen at the top, in A), which is released by a messenger. When it is desired to stop the apparatus, a second messenger is sent down which brings the catch into play again. The revolutions of the propeller are read on the dials seen in A, and from these the velocity of the current can be calculated.

The variations in direction are shown as follows: By means of an ingenious mechanism, small brass shot are allowed to pass through the apparatus at the rate of three for every hundred revolutions of the propeller. These fall upon the compass needle, shown at C, and run down the grooved arm, falling into some of the small compartments of the compass-box. As will be seen, the E. and W. points are reversed, so that the points shown by the box correspond to the direction in which the apparatus has been lying. The number of shot found in each compartment show for how many revolutions of the propeller the instrument has been pointing in that direction, and thus one can determine the main direction, strength and variations of the current during a given time.

We have tried the Current-meter, both in Port Erin

* See Ekman, Publications de Circonstance, No. 24, Copenhagen, 1905.

Bay and in the strong current near the Calf Island, but the use we have made of it as yet can only be regarded as for the purpose of practising with the instrument and testing the method, and has not led to any results that can be recorded.

HYDROGRAPHIC CONDITIONS.

In last year's report we had a section, by Dr. W. J. Dakin, dealing with the hydrographic observations he had made at Port Erin during 1909 in connection with our work, and their bearing on the planktology. No further observations on the same lines have been made systematically this year, and such as have been taken do not affect what was printed in the last report (Part III, p. 200). As usual, we have the ordinary meteorological records made on each plankton expedition, and also the records, in air and sea, taken twice daily at the Biological Station.

We insert here, for reference, the chart (fig. 2) of air and sea temperatures for 1910; and, for comparison, the similar chart (fig. 3) of the previous year—both made from the station records by Mr. H. C. Chadwick. It will be noticed that, compared with 1909, the sea temperature in 1910 was rather higher throughout the spring (e.g., in March), the lowest point (41° F.) being at the end of January, while in 1909 the temperature was at its lowest (40·5° F.) in the middle of March, six weeks later.

In 1910, the air temperature did not rise above that of the sea until the second week in May, and then remained above until the last week of August; and the sea temperature at the end of the year (47° F.) was higher than usual; but on the whole the sea-temperatures

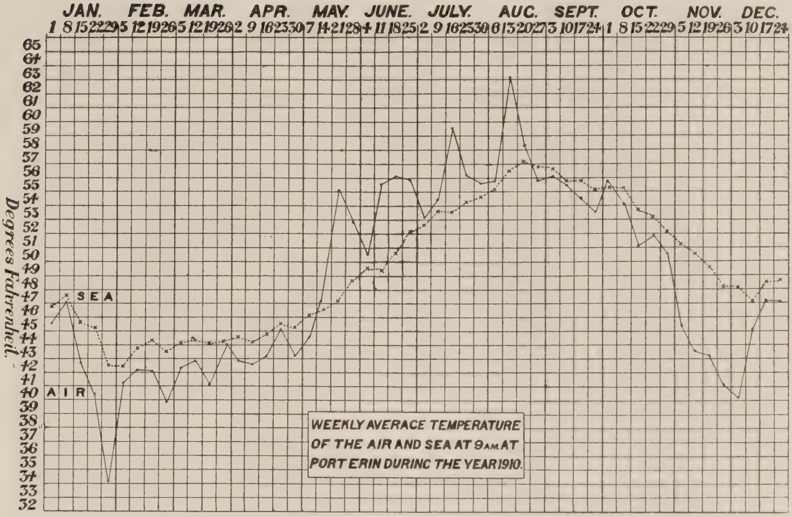


FIG. 2.

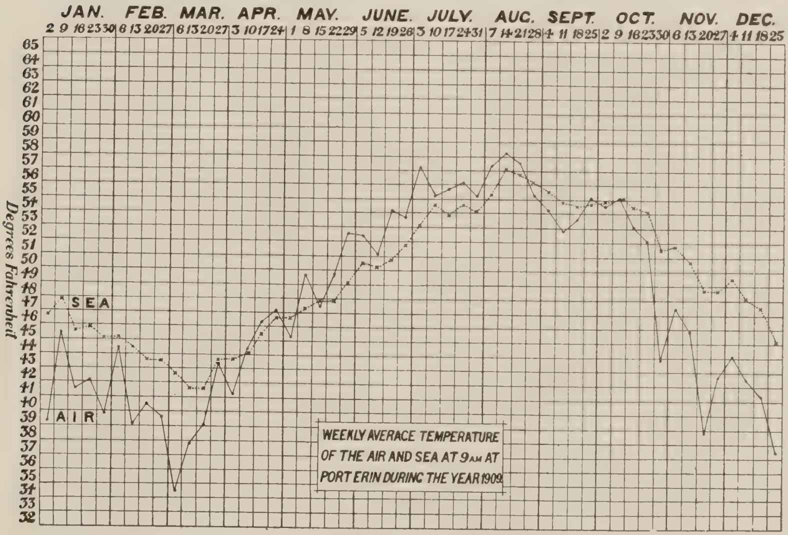


FIG. 3.

remain fairly constant in their annual course. A glance at the two diagrams will show the general similarity and the few points of divergence.

PLANKTONIC RESULTS.

Under this heading, as in previous years, we shall consider the plankton of Port Erin Bay and also that of the open sea outside, the distribution, both seasonal and topographical, of the more important groups, such as Diatoms and Copepoda, and of selected genera of these and other groups, the proportions of oceanic and neritic species in our fauna, the results obtained from certain nets, the relation of the plankton to physical conditions and its distribution in depth.

Plankton of Port Erin Bay.

Our plan of obtaining tow-net gatherings taken across Port Erin Bay on at least two days in each week throughout the year has been carried out most efficiently by Mr. T. N. Cregeen, the Assistant Curator at the Biological Station. Both fine (No. 20 silk) and coarse (No. 9) nets were used on each occasion, thus giving two hauls across the bay at the one time, the fine net being used in the traverse from South to North, and the coarse in the return journey from North to South. We have 204 such surface hauls, and they represent every week of the year from January 3rd to December 30th, 1910. The lowest numbers of hauls recorded for a month are 14 each in January and in June, and the highest number is 20 in April; most of the remaining months have 18 hauls recorded for each.

In addition to these surface hauls, we started this year the system of having one vertical haul taken on each occasion at the mouth of the bay, off the seaward end of the ruined breakwater, from a depth of 6 fathoms. Of these vertical hauls there are 92, making a total number of 296 gatherings from Port Erin Bay in 1910.

As the coarse and the fine nets as a rule catch very different assemblages of organisms, we consider that by adding the records of the two hauls together we get the best possible idea of the plankton obtainable in a traverse of the surface of the bay. We then take the numbers obtained by adding "coarse" and "fine" nets together as being what may be considered a standard haul comparable with a 15 minutes' haul of the two similar surface nets from the yacht in the sea outside. In January there were seven hauls of the coarse net, ranging from 1·0 to 3·0 c.c. in quantity of catch, and seven hauls of the fine net, ranging from 0·9 to 2·1 c.c., and if each pair of hauls taken on the one occasion be treated as one, the range for the month is 2·0 to 5·1 c.c., and the average double catch is 3·08 c.c.

In the following table the numbers of the Diatoms and other leading groups of organisms have been treated in a similar manner to that described above for the volume of the catches:—

TABLE I. **Monthly Averages for Horizontal Surface Nets, in Bay.**

1910.	Double hauls. c. + f.	Average catch in c.c.	Diatoms.	Dinoflagellates.	Copepoda adult.	Copepoda juv.	Copepoda nauplii.
January	7	3·08	19,994	953	5,679	497	2,014
February ...	9	2·17	43,871	1,214	1,770	199	1,777
March	8	5.37	381,662	1,419	858	337	5,919
April	10	63·35	11,505,577	8,913	7,371	5,105	15,630
May	8	61·18	5,870,037	15,375	7,912	2,656	18,437
June	7	36·11	9,812,612	59,121	33,634	5,718	21,526
July	9	22·98	2,181,002	69,722	51,234	5,662	24,227
August	9	11·66	850	11,467	34,394	2,258	32,360
September ...	9	15·58	676,823	19,027	42,170	2,638	36,378
October	9	13·1	553,601	5,122	30,371	3,849	19,689
November ...	8	4·96	100,262	730	8,590	776	2,929
December ...	9	5·74	48,391	2,205	6,352	497	1,689

We have now to add the additional information as to the plankton of the bay water obtained from the series of vertical hauls. The catches in this case are naturally much smaller in volume since a very much smaller column of water was passed through the net. The vertical haul strained about 6 fathoms, and the surface net perhaps on the average about a quarter of a mile, say 220 fathoms, or about forty times the amount. The volume of the surface catches is, however, not twenty times larger than those of the vertical net, which seems to indicate that there is a greater amount of plankton a fathom or two down than at the surface, a conclusion that agrees with what we found to be the case in the open sea in our previous work.

TABLE II. **Monthly Averages for Vertical Hauls, in Bay.**

1910.	Number of single hauls.	Average catch.	Diatoms.	Dinoflag-ellates.	Copepoda adult.	Copepoda juv.	Copepoda nauplii.
February ...	9	0·23	381	39	16	0	28
March	8	0·2	2,154	15	12	4	104
April	9	3·83	246,390	57	71	39	394
May	8	3·86	96,449	642	204	253	1,276
June	6	1·1	39,596	1,232	229	152	613
July	8	1·4	40,644	1,293	664	80	667
August	9	1·05	40	405	554	27	398
September ...	9	1·4	7,587	168	630	53	312
October	9	1·54	14,385	40	411	97	251
November ...	8	0·51	1,698	6	150	38	29
December ...	9	0·24	590	10	92	5	20

These tables bring out very clearly that the main Diatom maximum this year was in April, whereas last year the large catches extended well over April, May and June, and were heaviest at the end. In this, as in some other respects, 1910 seems to agree better with 1907, the first year of this series of observations, than with more recent years. The greatest monthly averages of both Diatoms and the total plankton are in April, the summer minimum of both is in July or August, after which in both cases there is a rise in September and October and then a distinct fall to the winter minimum.

It will be noticed that the outline of the curve drawn for the average catch will be much the same for Table II as for Table I, except that the maxima do not rise so high. A surprising feature about these tables is the large number of Dinoflagellates recorded. In Table I the monthly average scarcely falls below 1,000, and runs to five figures in each month from May to September inclusive. The maximum, in July, is unusually early. The Copepod maximum is also in July, but high numbers extend to September. These separate groups will, however, be treated more in detail further on in this report.

For the total plankton the highest monthly average was in April in 1907 and 1910, and in May in 1908 and 1909; while the greatest individual hauls, although in April in each of the four years, are much higher in 1907 and in 1910—and, in brief, the Diatoms appeared in great abundance earlier in April in 1907 and in 1910 than in the two intervening years. It is interesting to notice the correspondence between this planktonic result and the similarity shown by the hydrographic conditions this year with those of two years before*—and also with the sunshine records which we discuss below at p. 297.

The present year (1910) differs, however, from 1907 in having the average catch for May intermediate in bulk between that of April and that of June, and the catch for July again intermediate between June and August, so that the curve falls regularly from the maximum in April to the summer minimum in August, in place of going up and down in alternate summer months, as it did in 1907. We think it probable that the present is in that respect a more normal year, and

* See Bassett, Hydrographic Observations, &c., in this Lancashire Sea Fisheries Report, p. 125.

that the fluctuations in the summer of 1907 may have been due to some unknown factor or some unnoticed irregularity in the conditions.

The relatively high figure of the average catch for May this year (61·18), as compared with that of April (63·35), is clearly not due to phyto-plankton, as although the Dinoflagellates have increased to some extent, the enormously more abundant Diatoms have been diminished by about one-half (less than six millions as against eleven and a half). Some other more bulky organisms (such as *Sagitta* and the smaller Medusæ) have brought up unduly the average volume of the catch for May.

Annual Position of Chief Maxima.

We showed in last year's report that the three important groups of organisms—Diatoms, Dinoflagellates and Copepoda—had their vernal or summer maxima in a definite order of succession in all the three years (1907-09) there dealt with. When the curves are put together on the same sheet, the Diatoms occupy an earlier and the Copepoda a later position, while the Dinoflagellates lie between. We have now to add that in 1910 the chief maxima again occur in the same order—the Diatoms are most abundant in April and in June, the Dinoflagellates in July, and the Copepoda from July on to September.

The More Important Genera of Diatoms.

We add this year a seventh genus, *Lauderia*, to the six dealt with in our last report. This we do because the single species *Lauderia borealis* is of marked importance this year, running as it does to numbers over a million per haul on several occasions in April and

May. As the Diatoms are well represented this year, we think it worth while to print our records of these seven genera in full, in place of summarising the results as we did last year. The list that follows can be compared with the similar list for the five genera, *Biddulphia*, *Chaetoceras*, *Coscinodiscus*, *Rhizosolenia* and *Thalassiosira*, given in our Part II, for the year 1908, and with the remarks at p. 220 in Part III, for 1909.

Biddulphia.—Beyond being more abundant this year, *B. mobiliensis* shows no marked difference from the previous records. It has its chief maximum (half a million) in the middle of April, and a secondary one in early winter (61,000 on October 31st and 93,000 on December 5th).

Chaetoceras.—This is the most abundant form in the spring phyto-plankton, and this year it reaches the very high figure of nearly 49 millions in one haul on April 22nd. Its course through the rest of the year agrees with that of previous years, having a minimum in August and a second maximum in autumn, reaching nearly three millions per haul late in September and over one million on several occasions in October.

Coscinodiscus.—Here again, beyond showing higher numbers than on former occasions, there is nothing noteworthy.

Rhizosolenia.—Again, this genus is feebly represented until April, and has its maximum in June (13 millions on June 14th). It is absent during most of August, and has a somewhat sporadic secondary maximum in September and October (470,500 on September 26th).

Thalassiosira.—This is somewhat like *Rhizosolenia*, but is less abundant and has its spring maximum earlier

Date 1910.	Station.	Biddulphia	Chaetoceras.	Coscinodiscus.	Rhizosolenia.	Thalassiosira.	Guinardia.	La deri
Jan. 3	Bay	5,560	720	4,210	0	0	0	
6	,,	9,360	4,970	2,780	30	0	0	
13	,,	19,460	1,680	3,600	0	0	80	
18	,,	18,500	3,600	4,300	0	0	0	
21	,,	21,800	6,500	6,900	0	0	0	
24	,,	9,600	1,200	3,350	100	0	0	
29	,,	8,310	600	2,650	0	0	0	
Average for month ...		**13,227**	**2,753**	**3,970**	**19**	**0**	**11**	
Feb. 1	Bay	13,970	1,260	7,270	80	0	0	
5	,,	670	100	690	0	0	0	
8	,,	13,100	1,400	7,500	0	0	0	
12	,,	23,300	8,100	12,100	0	0	0	
17	,,	11,800	4,100	4,850	0	0	0	
19	,,	34,700	7,600	9,850	0	0	0	10
22	,,	42,600	8,000	14,900	0	0	0	
25	,,	50,000	12,100	16,100	0	0	0	
28	,,	61,700	11,300	13,200	0	0	0	
Average for month ...		**27,982**	**5,996**	**9,607**	**9**	**0**	**0**	**1**
March 3	Bay	68,700	5,600	13,500	0	0	0	
7	,,	64,100	16,600	8,000	200	0	0	
11	,,	56,700	9,500	20,100	0	0	0	
15	,,	74,100	40,900	88,600	0	0	0	70
19	,,	135,700	54,700	144,800	0	0	0	
22	,,	119,500	167,500	291,500	4,000	0	0	2,00
26	,,	620,000	219,250	204,000	4,000	2,000	2,000	4,00
29	,,	152,000	288,000	95,100	4,000	0	2,000	14,00
Average for month ...		**161,350**	**100,256**	**108,200**	**1,525**	**250**	**500**	**2,58**
April 1	Bay	155,000	579,000	71,000	4,800	1,200	6,000	22,00
4	,,	150,000	1,868,000	105,000	5,000	0	3,000	55,00
7	1½ miles out	210,000	1,650,000	210,500	9,000	45,000	4,000	25,00
	Bay	100,000	1,631,000	160,500	33,500	21,000	9,500	110,00
8	I.	132,000	460,000	96,000	38,300	14,000	1,200	18,00
	III.	199,000	2,334,500	111,200	78,500	254,000	32,000	184,00
	Bay	104,000	1,366,000	260,000	128,000	59,500	10,000	26,00
9	III.	365,000	1,044,800	103,000	32,300	140,000	40,000	100,00
11	I.	232,000	904,000	54,000	7,500	10,000	7,000	60,00
12	Bay	96,000	902,000	28,000	34,000	20,000	20,000	11,00
13	V.	53,500	8,055,000	52,500	127,000	155,000	70,000	1,370,00
14	Off Perwick	582,000	8,610,000	76,000	150,000	120,000	32,000	4,000,00
15	III.	44,000	11,296,000	8,000	92,000	404,000	68,000	4,200,00
16	III.	10,400	2,292,110	20,040	35,600	55,460	960	136,00
	Bay	50,000	13,310,000	66,000	140,000	98,000	104,000	1,760,00
19	I.	19,500	7,636,000	11,500	63,800	161,300	18,000	960,00
	III.	13,000	13,050,000	9,000	67,000	279,000	12,000	1,840,00
	V.	66,000	5,426,000	22,000	111,000	64,000	14,000	680,00
	Bay	80,000	11,812,000	34,000	105,000	16,000	40,000	1,240,00
20	Off Peel	48,000	18,220,000	14,000	1,210,000	571,000	18,000	1,480,00
21	I.	9,000	725,000	3,000	50,750	84,500	250	110,00
	III.	3,000	5,260,000	6,000	57,500	374,500	9,500	1,680,00
22	III.	5,200	1,878,000	2,600	22,800	25,600	4,600	300,00
	Bay	25,000	48,794,000	10,300	193,100	447,000	50,000	20,064,00
25	III.	10,400	1,180,000	1,900	19,800	29,000	300	376,00
	Bay	13,500	4,885,000	16,500	66,500	106,500	21,000	20,00
29	,,	4,750	1,230,000	3,350	56,000	151,075	3,250	612,00
Averages (Bay + Sea)*		**102,972**	**6,533,274**	**57,626**	**108,843**	**137,283**	**22,169**	**1,534,77**
Averages of Bay† ...		**77,825**	**8,637,700**	**75,465**	**76,590**	**92,027**	**26,675**	**2,392,00**

* In the case of April, August and September only. † For comparison with all the other months.

Date 1910.	Station.	Biddulphia	Chaetoceras.	Coscinodiscus.	Rhizosolenia.	Thalassiosira.	Guinardia.	Lauderia.
y 2	Bay	1,700	1,354,500	2,900	355,000	0	6,000	1,202,000
9	,,	2,250	1,686,500	8,500	921,750	31,000	59,000	560,000
12	,,	3,000	3,209,000	6,500	540,000	202,500	80,000	541,500
16	,,	1,500	4,610,000	6,500	1,680,500	613,000	218,500	1,348,000
19	,,	750	6,020,000	6,750	4,230,500	921,500	363,000	1,150,000
23	,,	0	588,600	2,500	6,240,000	3,000	240,000	2,000
26	,,	500	177,000	1,500	5,320,500	0	120,500	0
31	,,	300	4,700	600	80,300	0	11,200	0
Average for month ...		**1,250**	**2,206,287**	**4,469**	**2,421,069**	**221,375**	**137,275**	**600,437**
ne 3	Bay	0	56,500	325	4,479,000	0	7,300	100
7	,,	0	19,400	1,200	4,787,500	100	240,000	300
11	,,	500	35,000	1,500	9,421,500	0	8,773,000	0
14	,,	0	78,150	400	13,014,100	0	4,382,500	0
17	,,	0	8,900	500	7,165,600	0	3,002,000	0
20	,,	0	0	0	2,432,420	0	1,200,140	0
24	,,	0	4,000	0	6,290,500	0	3,240,000	500
Average for month ...		**71**	**28,850**	**561**	**6,798,660**	**14**	**2,977,848**	**128**
ly 1	Bay	0	1,500	0	5,161,000	0	48,500	0
4	,,	0	5,620	0	1,427,100	0	36,500	0
8	,,	0	3,000	400	1,256,400	0	18,400	0
11	,,	0	12,100	1,700	9,800,000	0	966,000	2,400
14	,,	0	600	600	827,600	0	600	0
18	,,	0	600	0	37,300	0	3,600	0
22	,,	0	1,000	450	2,150	0	0	0
26	,,	0	1,000	0	0	0	0	0
29	,,	300	500	100	800	0	100	0
Average for month ...		**33**	**2,880**	**361**	**2,056,928**	**0**	**119,300**	**267**
ugust 2	Bay	0	200	0	700	0	0	0
5	,,	0	1,150	0	300	0	0	0
8	I.	0	0	0	30	0	0	0
	Bay	0	320	0	260	0	0	0
10	I.	0	0	0	50	0	0	0
	III.	0	90	0	270	0	0	0
11	Bay	0	280	0	280	0	0	0
12	I.	0	0	0	0	0	0	0
	III.	0	50	0	0	0	0	0
	Off Fleshwick	0	50	0	0	0	0	0
13	I.	0	0	0	0	0	0	0
15	I.	0	0	0	0	0	0	0
	Bay	0	0	0	0	0	0	0
16	I.	0	0	0	0	0	0	0
18	I.	0	0	0	0	0	0	0
	III.	0	0	0	0	0	0	0
20	I.	0	0	0	0	0	0	0
	III.	20	0	0	0	0	0	0
	Bay	100	0	0	0	0	0	0
22	I.	0	0	0	0	0	0	0
	III.	100	30	0	0	0	0	0
23	III.	0	0	0	0	0	0	0
	Bay	0	820	80	0	0	0	0
25	Mid. Chan.	0	30	0	0	0	0	0
27	Bay	1,660	240	160	0	0	0	0
29	III.	950	420	30	90	0	0	0
	Off Niarbyl	140	0	0	0	0	0	0
	Off Fleshwick	120	0	0	20	0	0	0
	Bay	300	800	0	0	0	0	0
Averages (Bay + Sea)*		**117**	**154**	**9**	**69**	**0**	**0**	**0**
Averages of Bay† ...		**229**	**343**	**27**	**171**	**0**	**0**	**0**

* In the case of April, August and September only. † For comparison with all the other months.

Date 1910.		Station.	Biddulphia	Chaetoceras.	Coscinodiscus.	Rhizosolenia.	Thalassiosira.	Guinardia.	Lauderia
Sept.	2	Bay	0	3,100	0	300	0	0	0
	5	Off Spanish Hd.	1,000	6,200	0	700	0	0	100
		Off Aldrick	1,600	5,300	0	800	0	0	0
		Bay	600	33,400	200	800	0	100	0
	7	III.	0	14,900	0	482	0	0	0
	8	I.	0	10,580	0	1,560	0	0	0
		Bay	2,600	34,000	1,000	7,500	0	0	0
	9	I.	0	3,640	0	3,130	0	0	30
		III.	0	30,560	0	7,490	0	0	30
		Off Spanish Hd.	2,240	1,220	0	640	0	0	0
	10	Ballaugh Bk.	415	1,475	80	70	0	0	0
	12	Off Niarbyl	90	1,450	30	15	0	0	0
		Bay	1,900	59,750	100	1,100	0	100	0
	13	I.	0	170	0	160	0	0	0
		III.	0	40	0	10	0	0	0
	14	I.	0	120	0	0	0	0	0
		III	0	330	0	0	0	0	0
	15	I.	0	480	0	0	0	0	0
		III.	0	500	0	0	0	0	0
		Bay	100	67,000	0	2,200	0	0	0
	16	III.	0	6,400	50	100	0	0	50
		E. of Calf I.	270	101,480	520	18,080	0	140	0
	17	I.	0	1,530	0	200	0	0	0
		II.	0	0	0	80	0	0	0
		Mid. Chan.	0	270	0	90	0	0	0
		Off Perwick	0	3,960	1,200	300	0	0	60
	19	Bay	840	18,500	320	0	0	0	0
	24	,,	8,000	1,128,600	3,000	47,000	500	3,000	34,000
	26	,,	12,500	2,851,500	500	470,500	500	4,500	440,000
	29	,,	7,200	724,800	3,100	19,250	0	900	64,000
Averages (Bay + Sea)*			**1,312**	**170,375**	**337**	**19,419**	**33**	**291**	**17,942**
Averages of Bay† ...			**3,749**	**546,739**	**913**	**60,961**	**111**	**955**	**59,778**
October	4	Bay	6,400	12,160	1,700	280	0	1,600	140
	7	,,	3,000	1,527,500	8,750	60,500	1,000	0	151,000
	10	,,	7,050	363,000	11,400	7,900	0	0	0
	15	,,	7,000	1,025,000	5,000	63,000	0	500	1,500
	17	,,	16,980	582,500	4,040	4,960	0	200	1,360
	21	,,	12,520	350,480	4,790	11,060	160	80	640
	24	,,	39,100	272,680	5,920	17,400	800	0	2,400
	28	,,	38,320	139,640	2,000	3,260	0	0	80
	31	,,	61,020	48,230	3,200	2,450	0	0	100
Average for month ...			**21,264**	**480,132**	**5,200**	**18,900**	**218**	**264**	**17,469**
Nov.	3	Bay	30,500	95,500	1,650	650	50	0	0
	8	,,	40,000	86,020	2,860	960	0	0	1,440
	11	,,	14,520	29,900	1,700	420	0	0	140
	14	,,	13,180	24,980	4,880	100	0	0	0
	19	,,	63,750	54,796	3,180	0	0	0	50
	22	,,	54,500	64,850	8,450	150	0	800	800
	25	,,	48,420	48,510	2,060	0	0	0	0
	28	,,	30,600	45,390	1,880	400	0	0	0
Average for month ...			**36,934**	**56,243**	**3,332**	**335**	**6**	**100**	**304**
Dec.	1	Bay	56,130	33,960	6,360	0	0	50	0
	5	,,	93,520	32,240	11,360	0	0	320	0
	9	,,	26,640	8,640	2,780	0	0	0	0
	12	,,	17,170	2,790	1,450	100	0	0	0
	15	,,	20,080	3,680	1,820	0	0	0	0
	19	,,	15,840	5,400	3,840	0	0	120	0
	24	,,	9,000	2,400	9,440	0	0	0	0
	27	,,	8,290	2,930	3,300	0	0	0	0
	30	,,	21,950	5,330	4,900	0	0	0	0
Average for month ...			**29,847**	**10,819**	**5,028**	**11**	**0**	**54**	**0**

* In the case of April, August and September only. † For comparison with all the other months.

(half a million late in April, and nearly one million in May).

Guinardia, like *Rhizosolenia*, has its maximum in June (nearly nine millions on June 11th). It is absent in August and most of September, making a slight and short-lived reappearance at the end of that month and then dying off for the winter.

Lauderia.—The single species *L. borealis* is rare until April, then rapidly attains to a maximum of 20 millions on April 22nd, diminishes in May and June, is rare throughout the summer, and has a smaller second maximum at the end of September and in October.

The Indo-Pacific Diatom *Biddulphia sinensis*, which has appeared recently in our N.W. European seas, is again present at Port Erin in November in quantity.

It seems now, from its appearance in the gatherings, to be in much more vigorous condition than when it first occurred in the Irish Sea. The cells are seen to be in active division, and chains of two and four cells adhering together are quite frequently seen.

The above lists of the chief Diatoms show very clearly the marked Diatom minimum in August. From about August 12th to 23rd Diatoms were practically absent, then they reappeared and increased rapidly to form the second maximum early in October.

April, June and September Diatoms.

If we make out curves for the catches in the bay taken with the fine nets only—the nets that catch the bulk of the Diatoms at the times when they are most abundant—we find that in all four years after the April maximum there is a drop in at least the early part of May, and then more or less of a rise either later in May or in June; and this secondary rise, like the primary one in April, is mainly due to Diatoms, but to quite a different set of species from those that predominated a month before. The April Diatom maximum is formed in the main by species of *Chaetoceras* (*C. decipiens*, *C. teres*, *C. debile*, *C. sociale* and *C. diadema*) and *Lauderia borealis*, while that in June is caused by *Rhizosolenia semispina*, *R. shrubsolii* and *Guinardia flaccida*. In September the April Diatoms reappear to some extent, especially *Chaetoceras debile*, *C. decipiens*, *C. teres*, and to a less extent *C. densum*. *Lauderia borealis* is also present, but *Chaetoceras sociale* and *C. diadema* are practically absent in September. In fig. 4 we give curves for the distribution of these

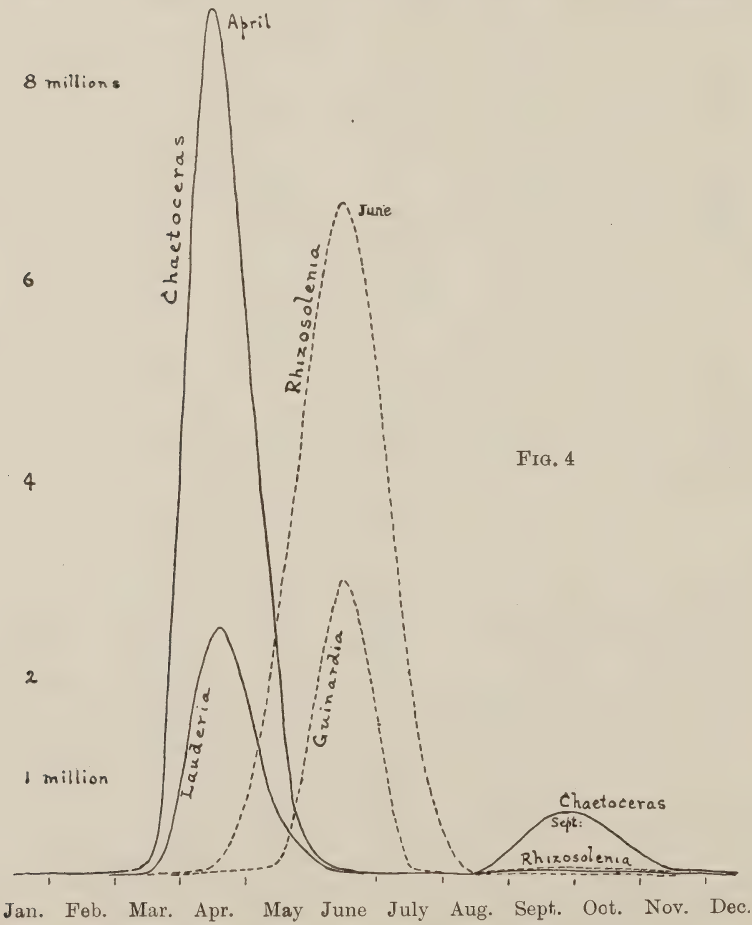


Fig. 4

Diatoms which show clearly the distinctness of those that form the April and the June maxima.

The distribution of these species throughout the years 1908 and 1909 agrees well with the above record for 1910; but 1907 seems somewhat different, as in that year *Chaetoceras contortum* and *Thalassiosira nordenskioldi* were very abundant species in April, and *Rhizosolenia semispina* reappeared in September in great quantity.

The Vertical Hauls in the Bay.

As is stated above, we have this year a series of additional hauls in the bay, taken near the entrance with the fine net raised vertically through six fathoms from the bottom to the surface. The net was sufficiently weighted to keep the tail extended vertically, and care was taken that only the weight touched the bottom.

The catches obtained, although naturally much smaller in bulk, give quite a satisfactory sample, and in their results throughout the year agree very closely with those of the surface nets.

We give here a diagram (fig. 5) showing the curve of total plankton throughout the year as given by the

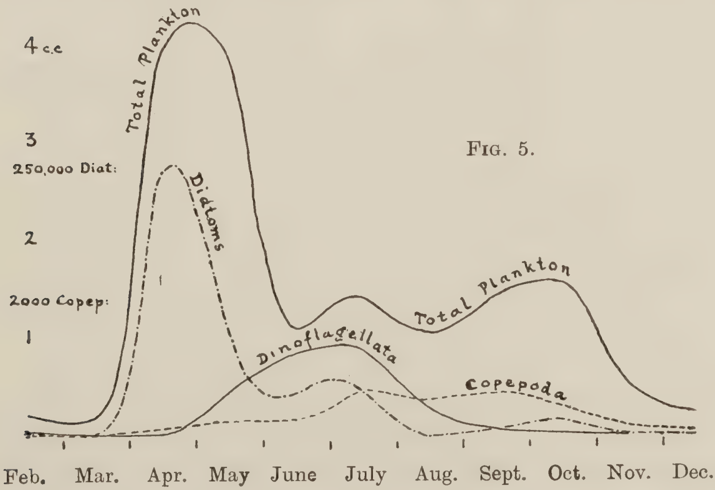


Fig. 5.

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vertical hauls, and also the curves for the Diatoms, the Dinoflagellates, and the Copepoda in these hauls. The way in which the maxima of these three groups follow in the usual order is quite evident. On the left hand margin of the figure, 4 c.c. represents the volume of the total catch at that level; 250,000 Diat: indicates the scale upon which the curve for the Diatoms is drawn; and 2,000 Copep: shows the relatively larger scale made use of for both the Copepoda curve and that of the Dinoflagellata.

Dinoflagellata.

Turning now from the Diatoms to the other Protista, we find that the Dinoflagellata and Noctiluca are both worthy of special consideration. The Dinoflagellates, although not comparable in importance with the Diatoms, are represented in our samples throughout the whole year, and in summer are present in considerable numbers, as we have shown in the tables on pp. 271 and 272. We have printed in the following lists all the records of the two types* *Peridinium divergens* and *Ceratium tripos*, both in bay and sea (the average of all the comparable nets used on each occasion). The results for the sea are enclosed in square brackets.

Date.		Ceratium Bay and [Sea].	Peridinium Bay and [Sea].	Date.		Ceratium Bay and [Sea].	Peridinium Bay and [Sea].
January	3	340	0	February	19	400	0
	6	175	0		22	300	0
	13	650	0		25	150	0
	18	300	0		28	100	0
	21	200	0	March	3	25	0
	24	150	0		7	550	0
	29	50	0		11	100	0
February	1	1,240	0		15	450	0
	5	145	0		19	600	0
	8	250	0		22	0	0
	12	450	0		26	1,050	0
	17	150	0		29	550	0

* Each of these may possibly include a few allied species or varieties or "forms"; under *Ceratium*, for example, we put any members of the *C. tripos* group.

April	1	550	0
	4	1,250	250
	7	750	0
		[333]	[333]
	8	1,000	0
		[200]	[125]
	9	[617]	[1,000]
	*11	[300]	[250]
	12	0	1,000
	13	[1,100]	[2,000]
	14	[2,500]	[6,000]
	15	[6,840]	[13,200]
	16	650	1,000
		[1,850]	[2,148]
	19	1,500	2,000
		[1,500]	[3,000]
	20	[1,000]	[5,800]
	21	[1,740]	[1,560]
	22	1,750	4,000
		[810]	[1,880]
	25	1,050	1,500
		[700]	[88]
	29	225	1,040
May	2	600	1,400
	9	500	3,750
	12	0	750
	16	0	1,750
	19	500	3,750
	23	1,000	3,000
	26	6,750	20,750
	31	2,450	8,650
June	3	12,000	9,900
	7	8,900	4,150
	11	6,250	7,000
	14	33,350	20,500
	17	12,600	16,000
	20	10,600	10,545
	24	13,750	2,000
July	1	12,250	7,750
	4	18,000	2,120
	8	8,100	700
	11	47,800	8,000
	14	69,000	10,100
	18	17,850	1,050
	22	2,550	700
	26	10,350	350
	29	14,650	850
August	2	10,450	300
	5	17,900	575
	8	10,040	280
		[312]	[0]
	10	[595]	[0]
	11	3,520	430
	12	[557]	[0]
	13	[457]	[0]
	15	3,300	705
		[127]	[0]
August	16	[75]	[0]
	18	[117]	[30]
	20	650	0
		[462]	[22]
	22	[180]	[20]
	23	560	80
		[305]	[110]
	25	[92]	[4]
	27	490	0
	29	800	0
		[1,637]	[40]
Sept.	2	9,500	100
	5	18,000	300
		[11,425]	[125]
	7	[4,300]	[20]
	8	15,750	0
		[7,099]	[50]
	9	[3,092]	[0]
	10	[1,187]	[10]
	12	7,300	0
		[1,285]	[5]
	13	[7,685]	[0]
	14	[4,625]	[0]
	15	8,100	0
		[4,762]	[20]
	16	[19,590]	[70]
	17	[3,812]	[25]
	19	10,980	80
	24	7,000	1,000
	26	1,000	1,250
	29	1,850	450
October	4	490	0
	7	3,750	125
	10	2,300	600
	15	1,750	250
	17	1,080	0
	21	1,270	0
	24	2,750	0
	28	1,760	0
	31	920	25
Nov.	3	800	0
	8	380	0
	11	60	0
	14	25	0
	19	300	0
	22	750	0
	25	60	0
	28	240	0
Dec.	1	25	25
	5	2,040	160
	9	780	0
	12	145	0
	15	700	40
	19	1,560	0
	24	1,840	0
	27	1,400	0
	30	875	0

* Part of catch lost.

This list of occurrences shows several points of interest. First, that *Ceratium tripos* is in the sea off Port Erin the whole year round—in every month the average haul runs to hundreds, and in most of them to thousands. Secondly, there is a well marked maximum in June and July, the highest figures being 33,350 in June and 69,000 in July; and although the numbers are less at the beginning and end of the year, they never get very low. It is difficult to speak of a "winter minimum" when such numbers occur as 2,040 on December 5th; 1,560, 1,840 and 1,400 on December 19th, 24th and 27th respectively; 650 on January 13th ; 1,240 on February 1st; and 1,050 on March 26th. *Ceratium tripos* is usually regarded as an "oceanic" species, but if that term implies an organism which is brought in by currents from the open sea and cannot continue to live and reproduce in our coastal waters, the above figures, showing relatively large numbers per haul at all times of the year, are difficult to reconcile with such an idea. We prefer to regard *Ceratium tripos* as a cosmopolitan form capable of living both in the ocean and on the coast. For such forms inhabiting practically all parts of the sea the term "panthalassic" may be employed.

On the other hand, *Peridinium* seems to be a much more typically oceanic species. It is absent during half the year, appears suddenly early in April (250 on April 4th, 1,000 on April 8th, 13,200 on April 15th), reaches its maximum in May (20,750 on May 26th, 20,500 on June 14th), and then diminishes to odd hundreds in the beginning of October, after which there are only rare occurrences of a few individuals. It is natural to regard *Peridinium* as an invasion from the North Atlantic, reaching its climax in May and then dying out.

Noctiluca.

The Protozoon *Noctiluca miliaris* is very abundant in the coastal waters of the Irish Sea in late summer and autumn, and is much rarer round the Isle of Man. In fact, it is probable that swarms sometimes abound on the Welsh and Lancashire coast without reaching Manx waters. A few years ago, before these intensive studies were started, we have a record of capturing *Noctiluca* in vast quantities off the North coast of Anglesey, in August, at a time when none were found in the tow-nets used at Port Erin. At Piel, in the Barrow Channel, as we stated last year, *Noctiluca* was present in September, 1908, to the amount of about 2,000,000 per gallon.

Its spread, during summer and autumn, on the West coast of England, is certainly from South to North. It appears first on the Welsh coast, gradually spreads across Liverpool Bay as the summer advances, and arrives in Morecambe Bay and the Barrow Channel about September. It does not usually extend far out to sea, however abundant it may be along the coast; and its occurrence this year in quantity round the south end of the Isle of Man in July is quite exceptional, and must have been due to some special conditions.

In 1910, at Port Erin, with the exception of small numbers on two days (February 1st and March 3rd) in spring, *Noctiluca* did not appear until after the middle of July. It remained in fair abundance (up to thousands and tens of thousands per haul) until late in September, and then slowly diminished in quantity to tens and hundreds at the end of the year. It is a neritic organism, rare in the first half of the year, but probably never completely absent from our shores. The highest numbers in the months of 1910 when it was abundant at

Port Erin are:—1,000 on July 18th, 57,000 on July 22nd, 10,000 on July 26th, 8,000 on July 29th, (few in August), 57,000 on September 16th (and 25,000 in another net), 8,000 on September 17th, 8,000 on September 29th. The highest number in October is 6,000, in November 2,000, and in December 400.

We shall now take out a few of the more prominent of the Metazoa from the bay gatherings throughout the year, and consider them separately.

Sagitta.

We discussed this type so fully last year (Part III, p. 241) that a few words now to bring the record up to date will suffice. The results for 1910 agree closely with those for previous years. Again the chief maximum is in summer, extending over June, July and part of August, and again there is a second but much smaller increase in numbers in October. The two greatest hauls from the ordinary horizontal nets were obtained in the bay on July 4th (1,015 specimens) and on August 5th (1,138 specimens). In a haul of the shear-net on August 8th at Station I, five miles off land, 3,200 *Sagitta* were obtained.

According to some planktologists, *Sagitta* is an oceanic organism. In our view it would be better to regard this and some other forms as "panthalassic" rather than oceanic, since they occur as freely in coastal waters as in the open sea, and their appearance in the in-shore plankton mixed with neritic forms cannot be regarded as an invasion due to an influx of oceanic water. *Sagitta* is present in Port Erin Bay all the year round. It was only absent from our bay hauls on two days, one in January and one in September, and it reproduces in the coastal waters.

Oikopleura.

The common short-bodied Appendicularian of our seas which we are calling *Oikopleura dioica* presents again the same form of distribution-curve throughout the year. It is present in every month, but is only abundant from April onwards nearly to the end of the year. The largest hauls were obtained in May, June and July, and again in September and October. The smoothed curve taken from the monthly averages shows a rounded elevation extending from April to July, and rising to its highest point, 6,000 specimens per haul, in June; and a second less extensive maximum in September and October, rising in September to over 5,500 specimens. Some individual hauls were, however, much higher than these figures. The two largest are 16,200 on June 24th and 14,900 on October 7th. All the above refer to Port Erin Bay. The hauls in the open sea outside do not materially affect the curve for the year, but the following exceptional hauls may be noted:—

April	14th	Off Port St. Mary	Coarse and fine nets	=	14,100	specimens.
,,	15th	Station III.	,, ,,	=	15,650	,,
,,	15th	,,	Otter net A	=	15,100	,,
,,	15th	,,	Otter net B	=	8,300	,,
,,	19th	,,	Coarse and fine nets	=	7,600	,,

Cladocera.

This is, in the main, a summer group in our seas represented by the two common neritic forms *Evadne nordmanni* and *Podon intermedium*. In 1910, both ranged from the middle of March to the middle of October, rather a wider range than usual. With the exception, however, of a remarkable haul of 1,600 *Evadne* in the coarse net, at Station I, on April 19th, neither genus becomes abundant until May. *Evadne,* on the whole, is earlier in its appearance than *Podon,* and is more constant in occurrence and more abundant.

The highest numbers for *Evadne* are:—1,750 on May 26th, 4,400 on June 7th, 1,400 on July 1st, 3,700 on July 4th, 1,500 on July 22nd, 1,100 on August 5th, after which the numbers are in tens and occasional hundreds, rarely above 200.

The *Podon* list shows 650 on May 26th, 1,700 on August 8th, 400 on August 23rd, and for the rest of the time the numbers are distinctly lower than those of *Evadne,* and are mostly under a hundred per haul.

Cirripede Larvae.

The seasonal distribution of the *Balanus* larvae outlined in our last report seems to hold good. Nauplii first appeared on February 8th in 1910 (February 6th in 1909), 100 in each of two nettings across the bay, reached 9,000 on March 19th, 11,000 on March 22nd, and the maximum of 145,800 on April 8th. After which they dwindle rapidly and disappear totally at the end of May. The "Cypris" larvae were few in number this year, indicating a very great mortality in the Nauplius stage. The first Cypris form was caught on April 1st, the greatest number, 900, was on April 7th; they continue to be present in small numbers in all hauls throughout May, less constantly in June, and disappear at the end of the latter month.

The records of the remaining Metazoa which do not seem to require individual treatment have been combined in the following table, and are shown in the form of monthly averages.

We may record here that on May 31st in the bay gatherings a sudden and remarkable change was noticed in the plankton. Diatoms were much less frequent than in the gatherings taken a few days before—and also than in those taken a couple of days later. But the notable feature of both hauls was the large catch of young Schizopods, which turned out on examination to be *Nyctiphanes norvegica*, decidedly a rare crustacean in our sea, though common in deep water on the West coast of Scotland. There were about 900 specimens of these young *Nyctiphanes* in the coarse net, and 160 in the fine. The swarm must have been a large one, and a very unusual occurrence inside Port Erin Bay in the surface waters.

	Medusae.	Echinod. larvae.	Sagitta.	Polychaet larvae.	Mitraria.	Gastrop. larvae.	Lamellibr. larvae.	Oikopleura.	Fish eggs.
1910.									
January ...	3	0	14	227	183	1,109	1,669	49	0
February	3	0	7	2,078	461	628	431	19	5
March	6	381	9	5,531	1,362	462	4,375	39	102
April	6	1,745	31	7,280	447	840	3,220	1,955	109
May	91	62	117	318	250	400	375	4,538	30
June	14	186	295	5,241	0	566	644	6,050	19
July	26	144	466	298	68	873	2,212	4,014	6
August ...	17	170	195	242	11	1,219	1,040	3,216	6
September	177	167	29	494	523	334	1,884	5,522	1
October ...	196	47	150	348	226	1,485	1,150	3,087	0
November	3	0	20	250	312	1,430	1,174	273	0
December	7	9	23	174	403	662	1,079	211	0

Of these, *Sagitta* and *Oikopleura* have been discussed above. The Medusae belong to many different species and even families, and several distinct curves probably overlap. The set that are abundant in May are probably quite distinct from those found in late autumn.

The Echinoderm larvae and the Polychaet larvae are most abundant in April, but here again different sets appear in succession during summer and autumn.

In the case of the Gastropod and Lamellibranch larvae also, we are dealing with many different forms, some of which appear in each month. The fish eggs, however, have a fairly definite season, and form a simple curve extending from February to September, with a well marked maximum in March and April. It is of interest to note that the eggs of Sprats, Gurnards and Rockling were present in the surface water as late as August.

Copepoda.

We have taken out the figures for about a dozen of the commoner species of Copepoda from each of the bay hauls throughout the year, but we think it unnecessary to print the full list, and will be content to make a few remarks as to the monthly averages and the largest hauls under the head of each selected generic name.

Calanus.—*Calanus helgolandicus* was again present during the whole year, although it is only in the middle of summer (July and August) that the numbers in our nets reach the thousands. During the first four months of the year only a few individuals were caught at a time. On April 25th the number rose suddenly to 300, and on May 31st to 600; during June several hauls were in the hundreds, July 1st and July 26th showed over a thousand, August 5th 4,300, and August 20th 600; September and October had a few hauls in the hundreds, and October 10th just reached 1,000. In November and December the nets took only units and tens, as in the early months of the year. The summer maximum is here rather earlier than in 1909—or, recognising the two summer maxima (or waves of invasion?) shown in our diagram (Part III, p. 230), we may say that in 1910 the earlier wave was the larger, the reverse of the condition in 1909.

Pseudocalanus.—*P. elongatus* comes next after *Oithona similis* as one of the most abundant of Copepoda in our district. It is present in our nets all the year round, and reaches thousands per haul in every month except February and March. It begins with 1,200 and then 1,600 in January, dwindles to units, tens and a few hundreds in February and March, reaches 6,000 and then 12,000 in April, remains at from 1,000 to 6,000 during May, 13,000 on June 24th, 12,500 on July 11th, 20,000 on August 8th, 26,800 on September 8th, up to 9,000 in October, 4,000 in November, and 5,000 on December 5th. Thus there seems to be a first maximum in April, and a second much greater one in August and September. The course of the species throughout the year corroborates that given for 1909, but the numbers are now larger.

Oithona.—*O. similis* is by far the most abundant Copepod in this part of the Irish Sea. Its numbers average double those of any other species. April is the only month where the numbers do not reach 1,000, and there is a well marked maximum of 126,000 on August 20th. Other high numbers were 83,000 in June, 49,000 in July, and 48,000 in September—higher numbers again than in previous years, although the same course through the year was preserved. There is an extended maximum in June, July, August and September.

Temora.—*T. longicornis*, unlike the last species, is absent during a large part of the year, and, in fact, only reaches thousands in April to September inclusive. Its maximum is 33,000 at the end of July.

Paracalanus.—*P. parvus* is also a species that is present during a part only of the year. In fact, it is abundant only in autumn and winter. It is rare in

February, practically absent in March, April, May, June, and the greater part of July. A few hundreds turned up on July 26th, it ranges up to 3,000 in August, 50,000 on September 8th, and 30,000 on October 4th. After that it diminishes rapidly to about 1,000 on several dates in October and November, 5,000 on December 24th, some hundreds in January, dying away in tens and units in February. The maximum of this species is in September, and the minimum in May.

ACARTIA.—*A. clausi*, although usually regarded as an oceanic species, is present in Port Erin Bay in all months of the year; it is, however, generally not abundant. It is in the thousands from May on to the end of the year, but the highest numbers in the bay gatherings are only 23,000 on July 18th and 21,000 on October 15th. A few hauls in the open sea, however, give higher numbers, viz.:—36,200 at Station I on April 19th; 30,000 in mid-channel on August 25th; and 280,410 taken in the shear-net at Station I on August 13th.

These are the six most important species of Copepoda numerically, and if arranged in the order of their abundance with their totals for the last two years they will come as follows:—

	1910.	1909.
Oithona similis	872,678	465,066
Pseudocalanus elongatus	368,326	309,973
Acartia clausi	340,631	63,373
Paracalanus parvus	217,633	54,120
Temora longicornis	147,043	62,659
Calanus helgolandicus	15,418	21,412

With the exception of *Calanus*, the numbers are all larger than in the previous year; but the order is in nearly all cases the same. The total in the case of *Oithona* is greatly increased, and far outnumbers all the rest. *Acartia* also shows a notable increase.

As we pointed out last year, the maxima of all these important Copepoda are in the summer and autumn months, May to October inclusive, when they constitute the main part of the zoo-plankton characteristic of the period when Diatoms are few or absent.

We add the following particulars in regard to a few other Copepoda which are less abundant but still have some importance.

ANOMALOCERA.—*A. pattersoni* is a large and brilliantly coloured form that is always very noticeable when present. Except for a very few scattered individuals it was only present in 1910 during April and May. The highest numbers are 220 at Station I on April 19th, and 264 in the bay on May 31st.

CENTROPAGES.—*C. hamatus* is never an abundant form, and only reaches thousands in July and August. It commences with a few individuals in the middle of March, increases to 400 in April, remains in the low hundreds in May, June, and most of July, just reaches 1,000 on July 22nd, and 2,700 on August 5th, is down to a few hundreds again in September, and practically dies out by the middle of October.

MICROCALANUS.—The puzzling case of *M. pusillus* was discussed so fully last year (Part III, p. 234) that we shall merely add now that in 1910 it was present in fair abundance during the first six months of the year, absent in July, August, September, and most of October, and present in small but increasing quantities in November and December. On this year's record it is a species with its maximum in winter and spring, unlike most of the other Copepoda.

The differences between the years in the distribution of this species are, however, so marked that we prefer to suspend judgment and re-discuss the matter after further observations have been taken.

On December 24th we had a remarkable haul of rare Copepoda in the coarse surface net on Port Erin Bay. In all, 14 species were represented by over 14,000 specimens; and the species included three, *Clytemnestra rostrata*, *Oncaea subtilis* and O. sp. (?), not previously recorded from the Irish Sea, and *Corycaeus anglicus*, which has only occurred here twice before (taken by Mr. I. C. Thompson in Port Erin Bay in November, 1898, and in May, 1899). These are all southern forms, and their presence is suggestive of some unusual drift of water up the Channel.

Comparison of Sea and Bay Plankton.

The plankton catches obtained from the yacht in the open sea during most of April show on the whole a curve resembling that of the bay plankton. The following catches on a few corresponding dates illustrate this:—

April	7th	8th	16th	19th
Bay	14	35	55	37
Sea	12	15	20	15

The sea curve is lower than that of the bay, and a little earlier in date. The catches are usually composed of the same species in the bay and outside.

The addition of the sea hauls would thus make no appreciable difference in the form of the curve for the bay plankton during the vernal maximum. In summer (August and part of September), however, there is a much less close correspondence. Both series of catches are then much smaller, they vary more from day to day, and the crests and troughs of the irregular curves do not agree.

Neritic and Oceanic Species.

We doubt the utility of attempting to divide all planktonic species into the two categories "neritic" and "oceanic." For reasons that are expressed elsewhere in this Sea-Fisheries Report* we are of opinion that some at least, possibly a considerable number, of the so-called "oceanic" species, are able to live indefinitely, and reproduce, in our coastal waters throughout the year; and that therefore their presence in in-shore gatherings, along with neritic organisms, must not be taken as an indication of an inflow of oceanic water.

The following species, usually considered to be oceanic, and most of them regarded as typical of named varieties of oceanic plankton, are commonly found throughout the year at Port Erin associated with neritic organisms:—

Chaetoceras decipiens (typical of "Chaetoplankton").
Coscinodiscus radiatus (not in large numbers).
Ceratium tripos (typical of "Triposplankton").
Sagitta bipunctata (with Northern "Styli-plankton").
Acartia clausi (with Northern "Styli-plankton").
Calanus helgolandicus (considered "Boreal Oceanic" plankton).
Oithona similis (considered "Boreal Oceanic" plankton).
Pseudocalanus elongatus (considered "Boreal Oceanic" plankton).
Oikopleura dioica (Temperate Atlantic).

As we have already explained in the case of *Ceratium tripos*, we would prefer to call such widely distributed species which flourish both in the open ocean and in the coastal waters by some such term as "panthalassic," and we consider it very doubtful whether it is safe to base any hydrographic conclusions upon their mere presence in a locality.

We have, however, for the sake of continuity, drawn

* Herdman and Riddell on "Plankton of the West Coast of Scotland in relation to that of the Irish Sea"—this vol., p. 132.

up the two following tables on the same plan as those for the previous three years given in our last report, and using the same lists of oceanic and neritic species as the basis, so that the tables for the four years may be comparable.

Table I shows the total numbers of oceanic species occurring on the days in each month when observations were made.

Table II shows chiefly the average number of days in each month when oceanic and neritic species respectively occurred.

TABLE I., 1910.	Jan.	Feb.	Mar.	Apr.	May	June
Total days worked	7	10	8	10	8	7
Total O+N	27	31	37	50	50	42
Total O	16	16	16	19	20	21
Percentage O	59·2	51·6	43·2	38	40	50

	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total days worked	9	9	9	9	8	9
Total O+N	39	32	49	50	44	46
Total O	20	17	21	22	21	26
Percentage O	51·3	53·1	42·8	44	47·6	56·5

The percentages of oceanic species shown in the last line afford the best basis of comparison with the similar tables given in last year's report; and they show the same tendency in the corresponding months:—January is more oceanic; February, March, April and May less so; June and July show an increase, while September and October are less, and December, like January, distinctly more oceanic.

	TABLE II., 1910.	Jan.	Feb.	Mar.	Apr.	May	June
Oceanic.	Total days worked	7	10	8	10	8	7
	Total number of species	16	16	16	19	20	21
	,, occurrences	87	117	78	133	118	114
	Mean occurrence	5·44	7·31	4·87	7	5·9	5·43
	Percentage of possible	77·7	73·1	60·9	70	73·7	77·5
Neritic.	Total number of species	11	15	21	31	30	21
	,, occurrences	44	67	100	212	137	87
	Mean occurrence	4	4·47	4·76	6·84	4·56	4·14
	Percentage of possible	57·1	44·7	59·5	68·4	57	59·1

		July	Aug.	Sept.	Oct.	Nov.	Dec.
Oceanic.	Total days worked	9	9	9	9	8	9
	Total number of species	20	17	21	22	21	26
	,, occurrences...	135	98	126	145	116	127
	Mean occurrence	6·75	5·76	6	6·59	5·52	4·88
	Percentage of possible	75	64	66·6	73·2	69	54·2
Neritic.	Total number of species	19	15	28	28	23	20
	,, occurrences...	72	63	119	161	112	90
	Mean occurrence	3·79	4·2	4·25	5·75	4·87	4·5
	Percentage of possible	42·1	46·6	47·2	63·9	60·9	50

On comparing the figures with those for 1909 (Part III, p. 255) we find a close agreement in the character of the months, there being only one out of the twelve which differs. August is this year more oceanic (as it was in 1907), while in the two intermediate years it was more neritic. From the tables for the four years now before us we can say that mid-winter (December and January) and mid-summer (July) are more oceanic in all cases, while the intervening months, and especially April and May and October, are in all four years neritic in character.

Sunshine and Phyto-plankton.

It is quite possible that Sir John Murray's original suggestion, that the great vernal maximum of phyto-plankton—perhaps the greatest and most important of biological phenomena in the sea—is simply the result of the increasing amount of sunlight in the early months of the year, may eventually turn out to be the correct explanation. In the meantime there are several other possible causes that have been suggested, such as Brandt's hypothesis that the fluctuations in the phyto-plankton depend upon the accumulation and the exhaustion of necessary inorganic food-matters in the water, perhaps the silica required for the shells of the

Diatoms, perhaps the nitrogen for their protoplasm, but none of these suggested explanations can as yet be either proved or disproved. Consequently, it is important that we should continue to collect any data that may seem to have a possible bearing on the matter; and we are now able to add an additional year's sunshine records to those given in our last report.

I. NUMBER OF DAYS WHEN SUNSHINE WAS RECORDED AT PORT ERIN.

	1907.	1908.	1909.	1910.	Average of 4 years 1907-10
January	9	10	8	11	10
February	14	11	15	15	14
March	20	17	13	21	18
April	10	22	18	20	17
May	15	23	30	24	23
June	16	21	25	24	21
July	19	20	19	24	20
August	20	17	23	19	20
September	16	16	21	19	18
October	12	16	19	18	16
November	12	11	13	13	12
December	6	7	13	10	9
Totals	169	191	217	218	198

It will be seen in Table I that 1910 had more days of sunshine than any of the previous years, and that every month except August was above the average of the four years in that respect. If we take the three first months of the year as being those in which increased sunshine might have an effect upon the spring phyto-plankton, we find that January, February and March of 1910, taken together, had eleven more days of sunshine than the corresponding period of the previous year, and five days more than the average of the four years.

II. NUMBER OF HOURS OF SUNSHINE.

	1907.	1908.	1909.	1910.	Average of 1908 and 1909.	Average of 1908, 1909 and 1910.	Average of 4 years, 1907-10
January	24¾	35	27	28½	31	30¼	28¾
February	58	28½	57¼	56½	43	47½	50
March	113	83½	77¼	100½	80¼	87	93½
April	69½	128¼	132¾	125	130½	128¾	113¾
May	103	179	198½	164½	188¾	180¾	161¼
June	81	154½	160	158¼	157¼	157½	138½
July	143	111	122½	188½	116¾	140¾	141¼
August	101	118	130½	80½	124¼	109¾	107½
September	121½	60	122	116½	91	99½	105
October	46¼	81	61	83½	71	75¼	68
November	44	55¼	58½	41	57	51½	49¾
December	13½	21	39½	25	30¼	28½	24¾
Totals	918½	1,055	1,186¾	1,168¼	1,121	1,137	1,082

Then, if we look into the number of recorded hours of sunshine on Table II, we find that January, February and March have in 1910 over twenty hours more sunshine than in 1909, and about thirteen hours more than the average of the same period in the four years. If we omit 1907 from the averages the predominance of 1910 becomes still more marked.

In short, the early months of 1910 had an unusual amount of sunshine, and so had those of 1907, and we have seen above that in these two years there was a much greater phyto-plankton maximum in April than was the case in the two intermediate years. The figures are given in the following table:—

	1907.	1908.	1909.	1910.
Hours of sun in Jan. + Feb. + March..	195¾	147	161½	185½
Hours of sun in March	113	83½	77¼	100½
Bay Plankton in April, per haul, in c.c.	18·3	8·1	7·0	31·7
Total Plankton in April, per haul, in c.c.	13·7	4·3	6·3	22·5

As it is possible that it is the sun in March that has most effect upon the April phyto-plankton, we have given also the figures for March alone in each of the years.

The Otter Nets.

In Part II of this report we referred to a criticism that had been made as to our surface nets towed from the stern of the ship, and in Part III (p. 288) last year we showed how a net towed from an otter-board at some little distance off the side amidships gave results that did not differ in any noteworthy respect from the similar net at the stern. In order to test the matter further, during 1910 we have used two exactly similar otter nets, one on the port and the other on the starboard side of the ship. If these two nets, towed simultaneously when going head to wind, show in their results just the same amount of similarity or of difference as two nets at the stern show, or as a stern net shows to one of the otters, then surely it is obvious that the surface nets towed over the stern are not appreciably affected by any action of the propeller in stirring up the water.

The evidence given by our experiments in 1910 is perfectly clear.

We have on record a series of twelve experiments made at various localities and under various conditions of weather, between April 13th and 25th, which show clearly that the two otter nets may differ as much from one another as either does from the similar net at the stern.

Date.	Locality.	Otter nets.	Stern net.	Date.	Locality.	Otter nets.	Stern net.
April 13	Stat. V.	43·0 c.c.	7·0 c.c.	April 19	Stat. V.	8·8	19·0
		45·5				19·0	
14	Off Port	39·0	37·5	20	Off Peel	25·5	29·5
	St. Mary	29·0				43·0	
15	Stat. III.	47·5	51·0	21	Stat. I.	8·2	5·5
		37·0				3·3	
16	Stat. III.	14·5	5·5		Stat. III.	7·5	6·5
		26·0				7·0	
19	Stat. I.	9·5	16·0	22	Stat. III.	6·3	2·7
		18·5				6·0	
	Stat. III.	10·0	6·0	25	Stat. III.	3·5	5·5
		8·5				4·2	

The figures speak for themselves, but we may just point out that the results on April 13th and 22nd, if they stood alone, might be taken to support the view that the stern net was under special conditions, whereas the otter nets, kept clear of the sides of the ship, and well in front of the propeller, gave a more normal catch. But the evidence of April 15th, 19th (both Station I and Station V), 20th and 21st (Station I) tell in exactly the opposite direction, and show that the two otter nets may differ more from one another than either does from the stern net. The rest of the experiments show in some cases a close similarity between the catch at the stern and that of one (e.g., on April 14th) or both (April 21st, Station III) of the otter nets.

In some cases the details show a close similarity between the catches of the two otter nets. For example:

	c.c.	Diatoms.	Dinoflag-ellates.	Copepoda. Adult.	juv.	nauplii.
April 13 Stat. V.	43·0	5,129,500	14,000	1,472	4,000	18,000
	45·5	4,417,200	9,000	1,248	2,000	16,000
22 Stat. III.	6·3	1,295,500	4,575	29	50	1,500
	6·0	1,523,605	3,525	46	25	1,000

In fact, one cannot escape from the conclusion that these nets give similar catches when the plankton is evenly distributed; and that when the nets differ much in their results it is an indication that the organisms are in swarms or banks or otherwise scattered unequally.

When a pair of hauls are fairly alike, as in the two instances given above, the figures probably give us a good idea of the degree of resemblance to be expected between two similar hauls taken through a uniformly distributed plankton.

These figures are useful and sufficient as an indication of agreement or difference, but are not accurate data that can be used as the basis for calculations as to the population of the sea or the exact quantity of any material in each cubic metre or gallon or square mile of the ocean.

Some "Pump" Plankton Experiments.

In the hope of being able to compare the plankton strained from a known volume of water with the catches made by our usual nets at the same time, we attached a hose to the donkey-pump in the engine-room and took the following samples by pumping a measured stream of water through the smaller "Apstein" net, at a variable rate but for a fixed time (15 minutes):—

No.	Date.		Station.	Rate of pumping.		Catch in c.c.
1	August	20	I.	6	gallons per minute	0·8
2	,,	22	I.	$3\frac{3}{4}$	,,	0·3
3	,,	23	III.	$7\frac{1}{2}$	,,	0·5
4	,,	29	Fleshwick	8	,,	0·5
5	September	8	I.	5	,,	0·5
6	,,	9	I.	7	,,	0·4

If we compare the first two of these by reducing both to the same rate of pumping, we find the catches are in the ratio 8 : 5; the coarse-net catches for the same dates give the ratio 8 : 5·15. Similarly the last two are in the ratio 7 : 4, while the coarse net on these dates gives 2 : 1. So far there seems to be fair agreement.

In other cases, however, the coarse net results do not agree with those from the pump. Thus if we take numbers 1 and 5 we get the catch-ratio 4 : 3, while the coarse-net catches on these dates give the ratio 11·5 : 3. In this case, however, the fine net results at the same time give exactly the same ratio as the pump catches.

It is quite possible, considering the small bulk of the catches and the difficulty of measuring them exactly, that these resemblances are merely coincidences, and have no real value. We propose, however, to make some further observations by this method in the hope that if a relation can be established between the plankton in the known volume of pumped water and that in our nets, it may afford a clue to the amount of water that has passed through the towed surface nets.

We hope also to make some observations during the coming year with the "Pump and Filter" methods of Lohmann.

CONCLUSIONS.

The most noteworthy fact that is made known as the result of this year's work is that 1910 in general resembles 1907 more than the intervening years. For the total plankton the highest monthly average was in April in 1907 and in 1910, and in May in 1908 and 1909. Again the individual hauls at the time of the spring phyto-plankton are much greater in 1907 and in 1910—in brief, the Diatoms appeared at an earlier date and in greater abundance in these two years than in 1908 and 1909. We have some evidence to show that there was also a similarity in the hydrographic conditions and in the sunshine records of 1907 and 1910, which may possibly be connected with the plankton variations.

We have shown that the spring and early summer Diatom maximum can be resolved very distinctly this year, and probably in other years also, into an April series and a June series, and that these are formed of distinct species, those in April being species of *Chaeto-*

ceras and *Lauderia*, while in June *Rhizosolenia* and *Guinardia* predominate.

Dinoflagellata were abundant in 1910, and the records show that *Ceratium* was abundant all the year round, while *Peridinium* is only present for the summer six months (April to October), with a maximum in May. The bearing of this and other cases of seasonal distribution upon the question of "oceanic" and "neritic" species is one requiring careful re-consideration.

In many other details which have been dealt with in this investigation we find that the records for 1910 agree with those of the preceding years, and support views that we have expressed in the previous reports.

A number of other groups, and some leading genera, are discussed in the report; but we abstain for the present from drawing any further conclusions in view of our intention, after a further year's records have been accumulated, of re-discussing fully the whole of the material available. We shall then have completed five years of this "intensive study" of a small area, and it is our hope that the material then before us will be sufficiently extensive to enable us to formulate some definite, reliable conclusions as to the meaning of the plankton variations in this part of the Irish Sea.